SCIENCE TODAY AND TOMORROW

# Adventuring in Science

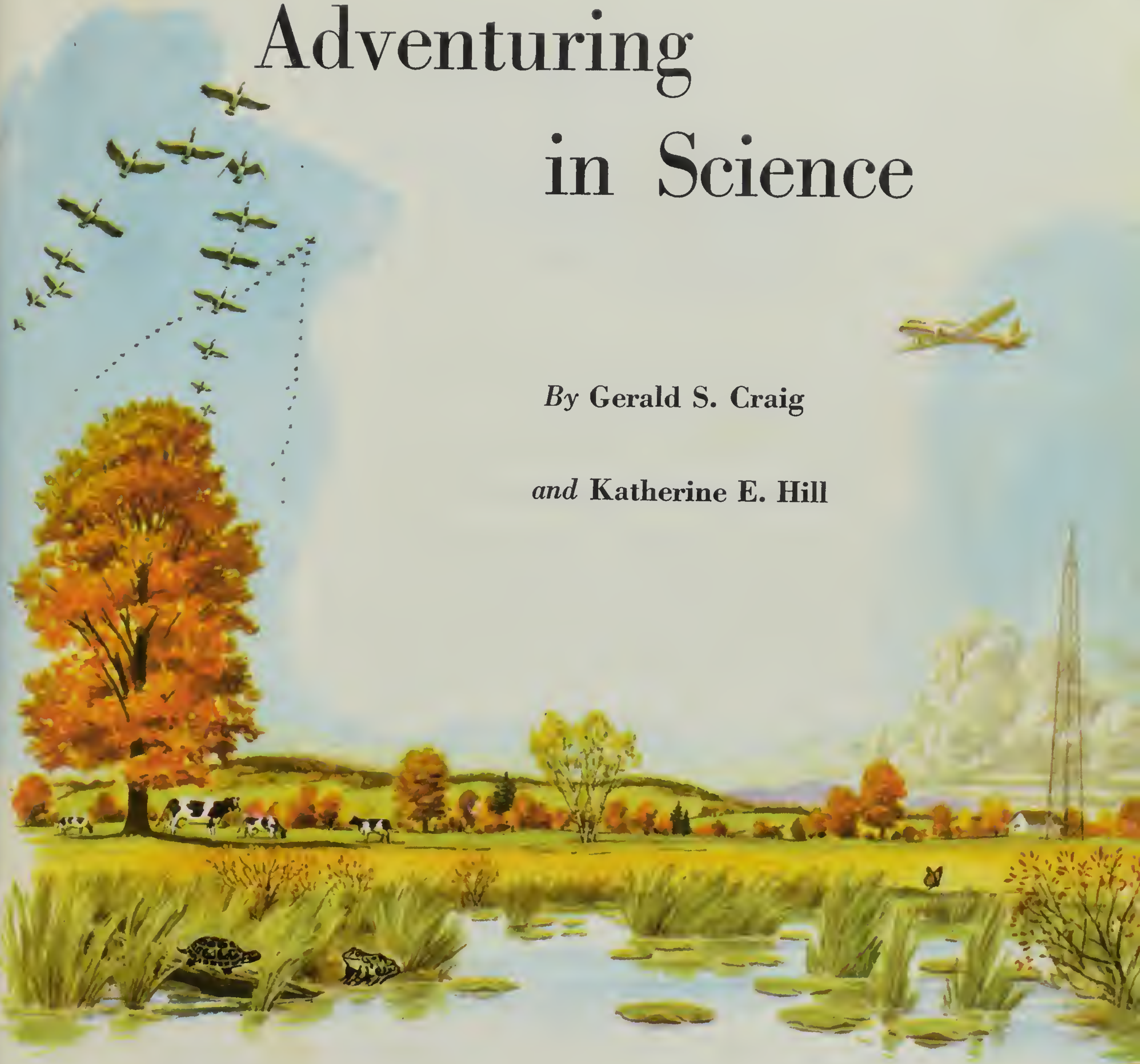
CRAIG | HILL

D

# Adventuring in Science

*By* **Gerald S. Craig**

*and* **Katherine E. Hill**



**Ginn and Company · Toronto**

PRINTED IN CANADA



T457.10

∧

# SCIENCE TODAY AND TOMORROW

*Science and You* (Primer) · CRAIG-BRYAN

*Science Near You* · CRAIG-BRYAN

*Science Around You* · CRAIG-DANIEL

*Science Everywhere* · CRAIG-LEMBACH

*Discovering with Science* · CRAIG-HURLEY

*Adventuring in Science* · CRAIG-HILL

*Experimenting in Science* · CRAIG-ROCHE-NAVARRA

*Learning with Science* · CRAIG-AREY-SHECKLES

*Facing Tomorrow with Science* · CRAIG-URBAN

*A Teachers' Manual accompanies each book*

*Drawings by* Robert Candy, Cheslie D'Andrea, Robert Doremus, Alma Froderstrom, James Jordan, Matthew Kalmenoff, Arthur Knapp, Martha P. Setchell, *and* Thomas W. Voter
*Maps by* New England Graphics

# Contents



# Plants Are Protected

## Trees Have Tough Stems

How beautiful deer are! They have sleek fur, slender legs, and graceful antlers. Deer use their antlers for fighting. Sometimes wolves hunt deer for food. If the wolves get near, a deer will use his sharp antlers for fighting.

You have probably thought of another way deer are protected. They can run very, very fast. In this way deer can escape their enemies. Deer hear very well, too. They are able to hear their enemies and run away.

Deer are protected in different ways—by their sharp antlers, by their fast-running feet, and by their very good hearing.

Look for something else in this picture that is protected. The deer is the only animal in the picture; so it must be that plants are protected. Yes, plants are protected in many ways.

The deer is standing near some large oak trees. These oak trees have thick, tough bark. Many trees have thicker and thicker barks as they grow older.


Here is a large oak log with a boy pointing to its bark. Notice that the bark is the outside covering of the log. The bark of an oak tree is tough.

Animals that feed on plants do not like to eat tough plants such as this large oak tree. The bark of oaks therefore protects them from animals.

A tough bark helps a plant in another way. It protects a plant from insects that might feed on it. Many kinds of trees are protected from insects in this way.

Strong tree trunks, protected by their tough barks, hold the branches up to the light. If you notice how many leaves and small branches there are on a tree, you will know that its trunk, or stem, must be strong.

Notice how a tree is blown back and forth in a strong wind. Think of how a strong trunk helps to protect that tree during a storm.

It would be interesting to find out which trees in your community have tough barks and stems. If you live in the northwestern United States or in British Columbia, you may find larch and spruce near your home or school.

If you live in California, you may find redwoods, which have thick, tough bark. In the southern United States perhaps you will find live oaks. If you live in some other region, you will find elms, oaks, or maples. All these trees have tough stems.

Wherever you live, you will probably find trees protected by thick, tough stems.

# Other Tough Stems

Trees are not the only plants with tough stems. Many smaller plants have tough stems also.

Some grasses are so tough that they do not make good food for cows and horses. A stiff, tough stem really protects these grasses. Such a stem makes these grasses poor food for animals.

Goldenrods, joe-pye weed, daisies, black-eyed Susans, and sunflowers also have tough stems. These tough stems are good protection.

You might like to form a committee to locate in your neighborhood some plants with tough stems. After you have found the plants, it might be fun to invite other children in your group to go with your committee to see these plants.

If you like, you might make a room or hall exhibit of plants that are protected by having tough stems. As you collect your plants, be sure to follow these rules:

1. Ask the owner if you may have a plant for your exhibit.

2. Take only one of each kind of plant for your exhibit.

It is not necessary to give the names of your plants. This is sometimes very hard to do. Just group your plants together with a sign that might read: "Tough Stems Protect Plants."

Indian paintbrush

Black-eyed Susan

## Many, Many Seeds

Plants are protected in still another way. Some plants have many, many seeds. Not all these seeds will grow. But because there are so many seeds, some are sure to grow into plants. Even though some of the young plants will die, others will live and grow.

After these larger plants flower, they will also produce many, many seeds. And so year after year new seeds become new plants. It is interesting to think that having many seeds is one way in which some plants are protected.

On these two pages you see pictures of plants that have many seeds. Some of the seeds are so tiny that they are hard to see. That is why they are shown on these pages under a magnifying glass. When you gather seeds, you too may want to look at them more carefully by using a magnifying glass.

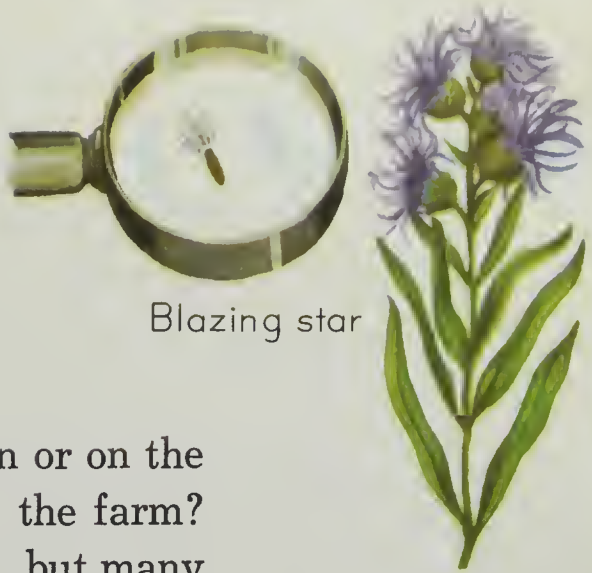
Quaking aspen



Heart-leaved aster

California poppy


Dandelion


Blazing star

Which of these plants grow in your garden or on the school grounds or along the roadside or on the farm? Perhaps not all of them grow where you live, but many of them probably do.

The beautiful California poppy grows wild in California. The yellow and orange flowers of this poppy are so gay that people in many other places plant its seeds in their gardens. Do you see the long, green seed pod? The many, many seeds of the California poppy grow in this pod.


Honey locust

Dandelions grow wild almost everywhere. They too have gay flowers. Sometimes they grow on lawns, but we do not like to have them there. When the dandelion flower is old, its many seeds fly away in the wind.

The aster, blazing star, sunflower, blue vervain, milkweed, maple, Queen Anne's lace, oak, goldenrod, and Indian paintbrush are only a few of the plants that have many seeds.




Blue vervain


Milkweed

Mold on cheese

Mold on orange

## Many, Many Spores

Perhaps *spore* is a new word to you. You may never have used this word, but probably you have seen spores.

Sometimes an orange or a lemon spoils, and we are not able to use it. Very often this happens because there are plants growing on the fruit. These plants are molds.

Molds do not poison the oranges or lemons, but they make them taste queer to us. If we were very hungry, we probably would not mind the taste of these plants that grow on the fruit.

When molds grow on fruit, they make it soft too. This is because molds do not make their own food. They use the fruit on which they grow as food. After a while the fruit that they use as food spoils.

Molds do not have flowers. They do not make seeds. Instead they make spores. A new mold plant could grow from each spore if the spore had the right amount of heat, water, light, and food.

Having many, many spores is a protection for molds. Even though many of the spores never grow, there are enough spores so that some of them do grow. So year after year new molds grow.

Some fruit molds have a greenish or bluish color. Molds that grow in other places may also look black, green, or even blue or white.

A black mold often grows on bread. Perhaps you would like to try to grow some black mold on pieces of bread. You may want to try growing mold on fruit too.

A mold garden is not hard to grow. Are you wondering where to get the spores with which to start your garden? There are no spore stores, as there are seed stores. You would not even be able to order a package of spores.

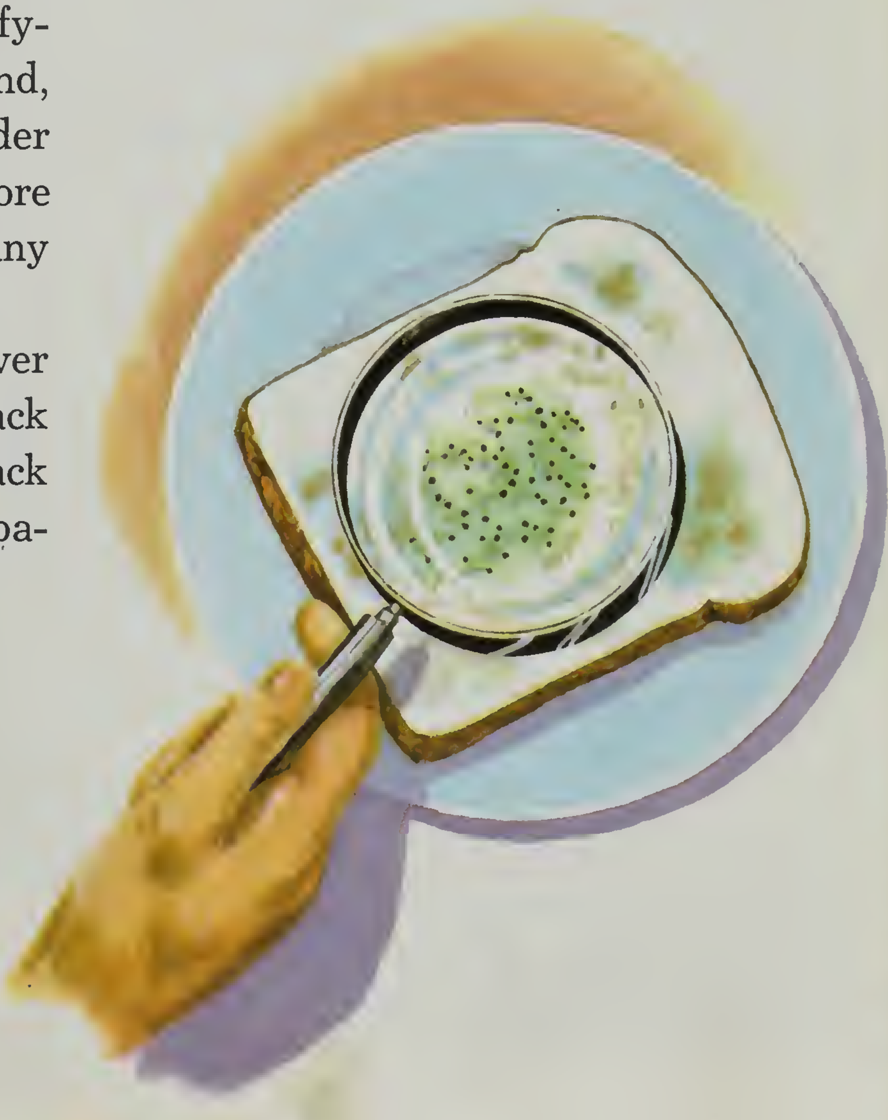
Just put a piece of bread in a saucer. Put enough water on it each day to keep it damp. Put the saucer in a place where sunlight does not reach it. Before very many days the bread will probably have black mold beginning to grow on it. The mold will feel soft and fuzzy.

Wait a few more days and then look at your mold with a magnifying glass. You will see small, round, black balls on the ends of slender stalks. These round balls are spore cases. Inside them are many, many tiny spores.

Pinch one of the spore cases ever so gently. Now notice the black powder on your fingers. This black powder is made up of many separate spores.

Add an orange and a lemon to your mold garden. Keep them in a warm place. You will not need to dampen them, because they contain enough water to keep them moist. After a few days mold will probably begin to grow on the fruit.

Now you see why we do not need spore stores or packages of spores in order to grow bread and fruit molds. The tiny spores of these plants are often blown about in the air. Those that settle in the right place will begin to grow.



Rules for growing a bread-mold garden:
1. Keep bread warm
2. Keep bread away from direct sunlight
3. Keep bread damp

# Molds and Mushrooms

Some molds are good to eat. If you have ever eaten bleu cheese, you have eaten mold. The mold that grows in this cheese has a sharp taste. People who make bleu cheese are very careful to keep other molds away from the cheese. They let only the bleu-cheese mold grow in the cheese.

Some molds, such as penicillin, are used in treating certain diseases. The people who take care of special molds used as medicines are careful not to let other molds grow with them.

Molds are not all alike. They have different colors. Some are useful, and some are not. But molds are alike in some ways.

Molds are alike because they are plants that cannot make their own food. They are also alike because they have spore cases. And each spore case has many, many spores. Having many spores is a protection for molds because some of the spores will grow into new plants.

Molds and mushrooms are alike in certain ways. They are plants that cannot make their own food. Both produce many, many spores.

Some mushrooms are sometimes called toadstools. Mushrooms grow deep in the woods, on the edge of woods, and sometimes on lawns. No one plants them there. Mushrooms grow in different places because the wind carries their many spores to these places.

Try to find some mushrooms near your home or school. Bring one to school. If mushrooms do not grow near your home, perhaps you will be able to buy a few fresh ones from your grocer.

Put a mushroom on a piece of white paper and leave it for a few days. The mushroom will begin to dry. After a while a dark powder will fall on the paper. This dark powder is made of many spores.

This powder is made of the spores from the mushroom. The spores grow in the little slits on the underside of the top of the mushroom.

Some mushrooms are good to eat. But remember that some are very poisonous. Never taste a mushroom unless it has been bought in a grocery store or picked by someone who knows which mushrooms are poisonous and which are not.

Do you know that there are mushroom farms? These are not outdoor farms. Mushroom farmers have many boxes filled with soil. The boxes are kept in caves or cellars or some other moist place that is kept dark and warm.

Mushroom farmers, like the man in the picture above, are careful to have the right kind of spores growing in their boxes. These spores are the ones that will grow into mushrooms safe to eat.

Molds and mushrooms are well protected. If they did not produce so many spores, molds and mushrooms might soon die out.

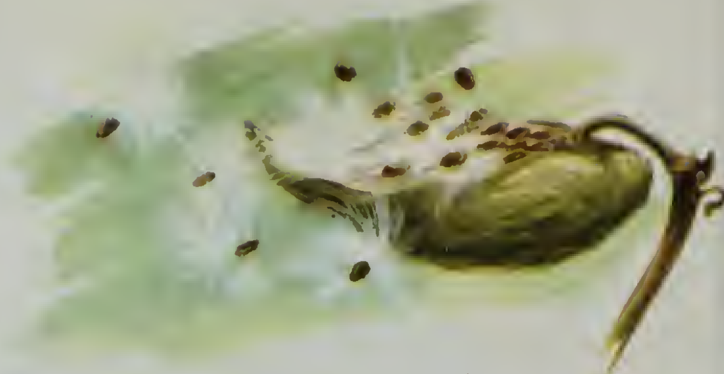
The many seeds of some plants and the many spores of others are a protection to these plants in still another way.

Seeds and spores may be formed in one place, but they may not grow into new plants in that same place. Seeds and spores may grow into new plants in a place far away from the parent plant.

The reason for this is that many seeds and spores are carried from one place to another by wind, by water, or by animals. In this way some of the spores and seeds may be in a better place for growing. So there would be a better chance for new plants to grow.

Bull thistle

Maple



Milkweed

# Flying Seeds

Wind blows seeds to new places. Sometimes the wind causes seeds to roll along the ground. But some seeds that are light are blown about easily. Some seeds are so small and so light that they are blown about as easily as dust is.

Other seeds are shaped in a way that makes it easy for the wind to blow them about. Milkweed seeds have long, silky threads attached to them. The wind often blows these seeds long distances.

When you are outdoors in the fall, gather some milkweed pods. You will find many seeds in these pods. When the seeds are dry enough, you will be able to blow them out of the pods and into the air. Notice how the silky threads help the seeds to float in the air.

White elm



Longleaf pine

Cotton

White ash

Clematis

Milkweed seeds may be carried long distances by the wind. They may fall in a place where milkweed plants have never grown before. Look at the pictures of seeds that have threads attached to them. Which of these seeds are found where you live? Do you know any other seeds with threads?

Some seeds have wings, or sails, that help them to float about in the air. Notice the pictures of seeds of the maple tree and of the box elder. You can see how easy it is for these seeds to be whirled along to new places by the wind.

The seeds of white ash and longleaf pine each have one wing. This wing helps the seed to sail and whirl along through the air. If there are ash trees or pine or spruce trees in your neighborhood, try to find some of their winged seeds. Toss them up into the air and watch them whirl about as they float down to the ground.

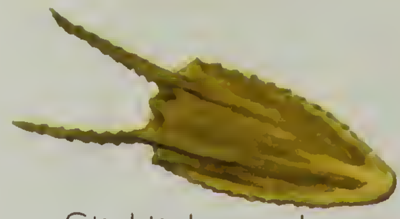
Sand-bar willow



Box elder

Cottonwood

Cocklebur seed



Sticktight seed

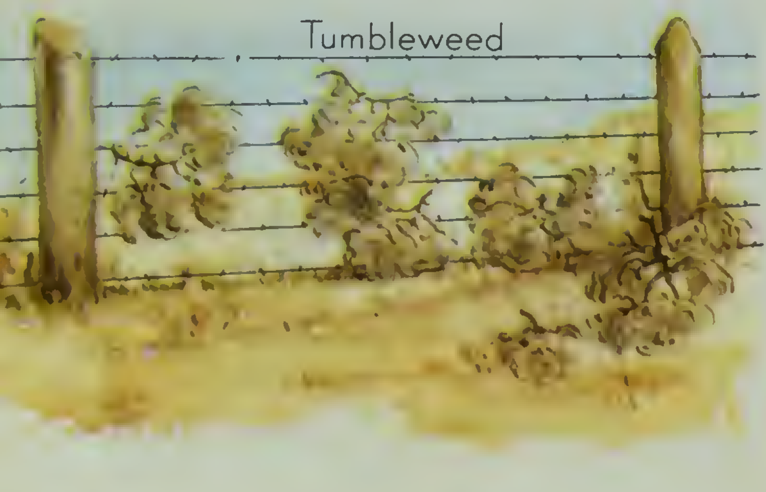
## Seeds That Float, Tumble, Slide, and Ride

Some seeds float on water to new places. The wings on such seeds help them to float for a long time. If they are washed ashore, these seeds may grow in new places.

Cypress, cottonwood, birch, elm, and maple seeds can float down a brook or a river for long distances. Then they may be washed ashore.

Coconuts can also float in water. Ocean currents may carry a coconut from the island where it grew to another island. On the new island the coconut may grow into a tree.

Seeds that fall into water do not always reach a new, good place to grow. But those seeds that do float to a new place may be in a better growing place.



Tumbleweed

Have you ever had a picnic in the woods in the fall? If you have, perhaps you have sat very quietly, listening. Try to remember some of the sounds you heard.

Did a bird call? Did you hear a squirrel chatter and scamper about in the dry leaves? Did the wind whisper through the trees?

Then, plop! Did a nut fall near you with a sharp crack?

If there were nut trees in the woods, you probably heard seeds falling. Pecans, walnuts, acorns, and hickory nuts are all seeds of trees. These seeds fall to the ground and sometimes tumble or roll downhill.

The seeds of the tumbleweed are scattered in a strange way. Tumbleweed is a plant that dries up and is blown about over the land. As it tumbles, its seeds are scattered. It may be that these seeds are moved to a better growing place.


Burdock seeds


Devil's-claw seed

Other seeds are scattered when strong winter winds blow them along the ice on lakes and streams. As the seeds slide along the ice, they may be carried from one shore to the other.

They may stop in a good growing place. It may be a good growing place because fewer plants or more moisture or more light is in the new place.

Birds carry seeds of the hackberry tree to new places. The soft outer covering of a hackberry seed is good for a bird to eat. But the hard seed is not. So the seed is dropped to the ground.

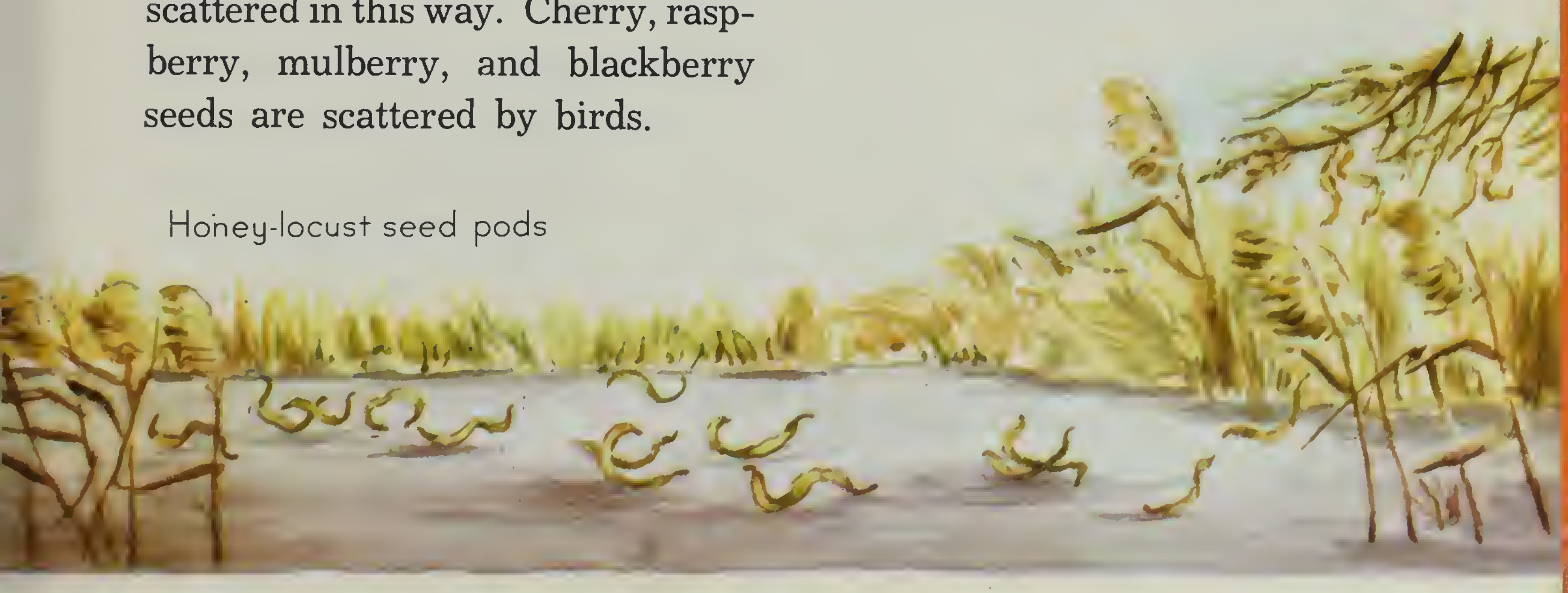
Often birds pick fruit from a tree or vine and fly to another place to eat it. The seeds of the fruit are scattered in this way. Cherry, raspberry, mulberry, and blackberry seeds are scattered by birds.

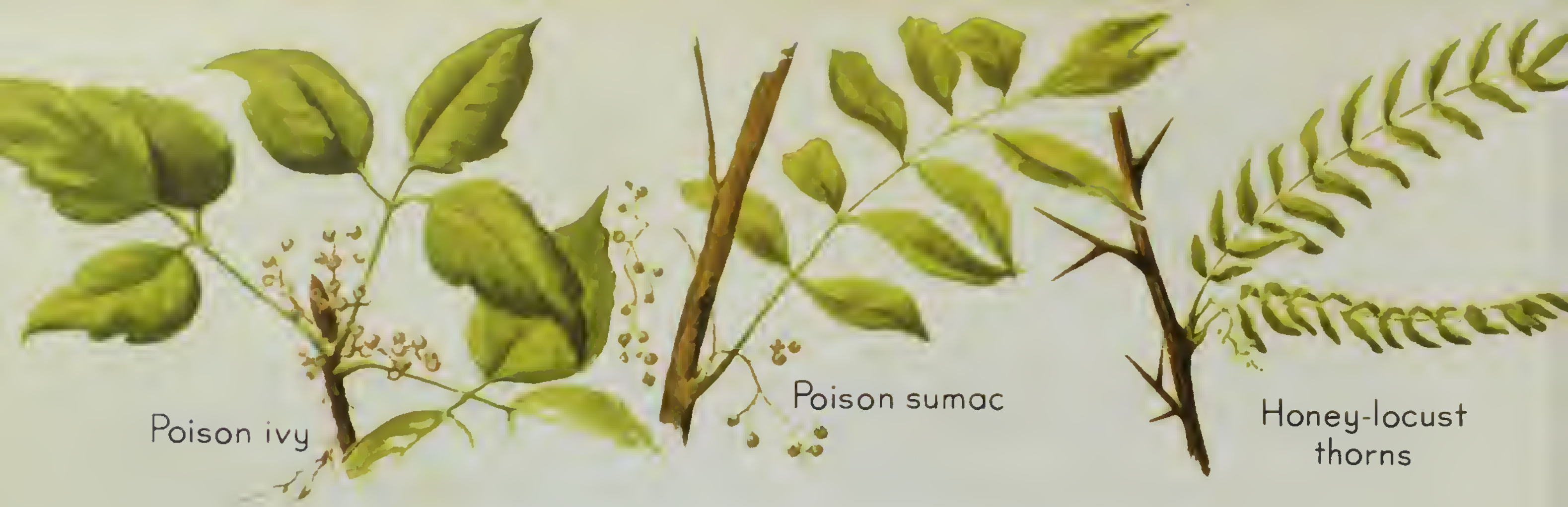
Squirrels and chipmunks carry acorns and other nuts to new places. They do this when they hide seeds for winter food.

Animals often carry seeds to new places in their fur. Some seeds, such as those shown at the top of these two pages, will catch easily in the fur of animals. Have you ever carried seeds such as sticktight or cocklebur seeds from one place to another? These seeds often stick to clothing.

So by having their seeds carried to new places, plants are protected. The new places may be good growing places. This kind of protection is the kind that protects plants from one year to the next. In this way new plants grow in new places.

Honey-locust seed pods






## Spines, Stings, and Poisons

If you have ever picked roses or blackberries or raspberries, you have probably found another way that plants are protected. They are protected by having spines or thorns.

These spines and thorns hurt our fingers, legs, and arms, and so we are careful when we are near these plants. Because of this we think about getting hurt and do not injure the plants as much as we might. For instance, we often use scissors to cut roses. This is much better than trying to break off a rose.

There are a number of other plants that have spines or thorns. Many cactus plants have very sharp spines, which hurt the mouths of animals. The spines keep cattle and other animals from using the cactus plants as food.

Many other plants have spines or thorns on their twigs, leaves, or branches. Some of these plants are thistle, holly, prickly ash, barberry, hawthorn, crabapple, and locust.

Some plants are well protected because they make our skin sting or itch. Nettles and itchweed are protected in this way.

Then there are the plants that are poisonous to many of us. If some of the juice, or sap, of these plants touches our skin, we may have painful blisters.

One of the plants with this kind of protection is poison ivy. Another is poison sumac. If these plants grow in your neighborhood, learn to know them. Then be very careful to stay away from these poisonous plants!

## Some Plants Have Armor

Some palms have a kind of armor on their tall trunks. If you have ever seen the outer covering of a palm's trunk, you know that it is not like the tough, woody bark of an oak or a maple.

The bark of some palms is ridged, so that it looks something like a turtle's shell. This outer covering is a good protection for the soft part inside the trunk of the tree.

The fruit of pineapple plants also has an outer covering that looks something like armor. This outer covering is tough. In this way the soft, juicy inner part of the pineapple is protected.

Pineapple

California date palm

# Wide-spreading Roots and Deep Roots

Roots are also a kind of protection to plants. Some plants have wide-spreading roots. These roots do not grow deep down in the soil, but spread out through the soil.

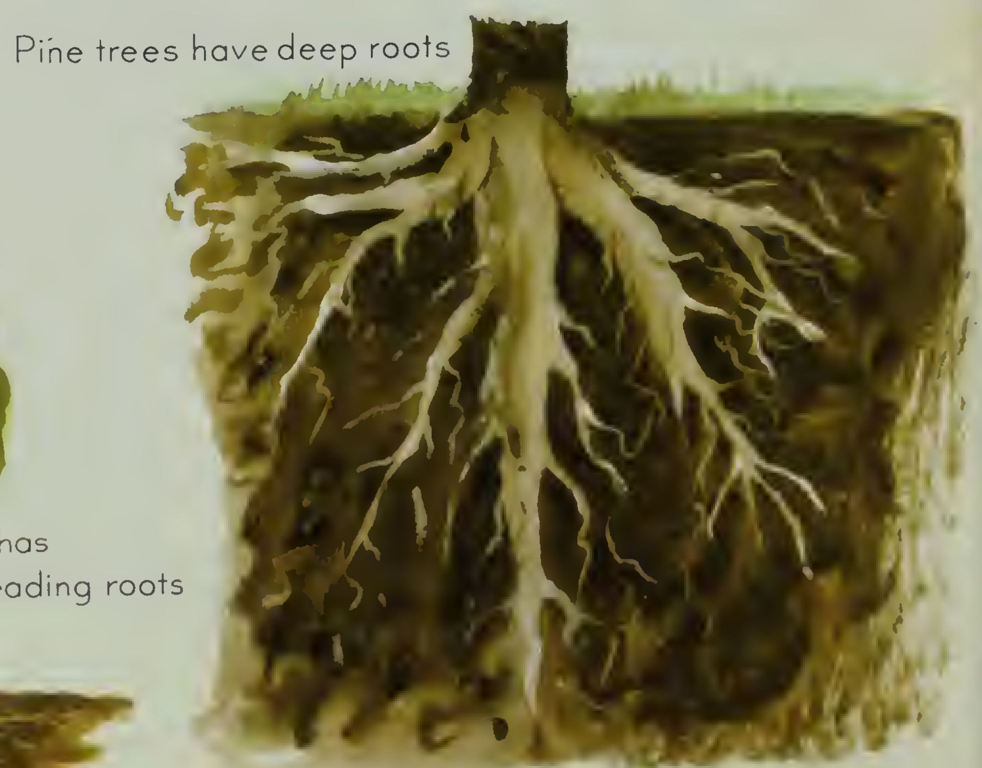
Plants having this kind of root usually grow quickly in places where water falls on the soil and then drains away rapidly. This is especially true of some of the desert plants, such as the desert primrose. These plants, with their beautiful flowers, grow from seeds, bloom, and die within a few weeks.

Their wide-spreading roots take in water quickly. This is necessary because the desert rainy season does not last very long.

Corn is another plant that has wide-spreading roots. These wide-spreading roots are good for taking in water quickly. They also help to hold the corn plant in the soil. You have probably seen corn swaying in the wind. If the corn did not have a good, sturdy root system, it would be blown over.

Wide-spreading roots, then, are a real protection for some plants.

The roots of some other plants grow very deep. These are often the plants that do not die each season, but keep growing year after year. Because these plants grow each year for many years, their roots have a chance to grow deep.

The deep-growing roots are a protection for these plants, just as wide-spreading roots are a protection for others.

Oaks, redwoods, spruces, pines, and other large plants have very long roots. These trees, growing year after year, need much water. The deep roots reach far down into the earth. They take in the water that is deep in the soil.

Long, deep-growing roots help to hold a tree steady. If a tall pine tree had only wide-spreading roots, the whole tree might be blown over in a bad storm. The long, deep roots hold the tree firmly in the earth.

Whether they are wide-spreading or deep-growing, roots are a protection for plants.


## Leaves May Be a Protection

Some plants have so many leaves that it would be hard to count them. Think of trying to count all the leaves on a rosebush or an oak tree!

A plant that has many leaves is protected against the full force of the rain. Rain strikes the leaves and then falls gently around the roots of the plant. Then less soil is washed away.

It is easy to see why plants that grow in a place where there is little rain might have few leaves. Since there are so few leaves, less water is given out into the air. This is another protection for some plants.

Some plants, such as cacti, have very few leaves. This is a protection because it helps the plants to keep their water.

## Some Plants to Protect

Arizona—desert lily, shooting star, primrose
British Columbia—false lady's-slipper, Easter lily, flowering dogwood
Florida—jasmine, dogwood, mountain laurel
Illinois—bloodroot, columbine, lotus, trillium, gentian
Maine—early yellow violet, harebell, mountain laurel
Manitoba—grama grass, ground hemlock, lady's-slipper
Michigan—bird's-foot violet, native orchid, gentian, trillium
Minnesota—trillium, gentian, trailing arbutus, lotus
New York—moccasin flower, trailing arbutus, dogwood
Nova Scotia—trillium, lady's-slipper, trailing arbutus
Ontario—trillium, water lily, lady's-slipper
Pennsylvania—hepatica, bluebell, redbud, trailing arbutus
Saskatchewan—prairie lily, lady's-slipper, great-flowered gaillardia
Texas—redbud, Texas bluebonnet, jessamine, Indian blanket
Vermont—alpine goldenrod, pale painted cup, butterwort
Wisconsin—dogtooth violet, spring beauty, pitcher plant

## People Protect Plants

Above are some of the flowering plants that we need to protect in certain states and provinces.

If your state or province is not in the list, write to your department of conservation. Ask which flowering plants in your state or province need to be protected. Now let us try to understand why certain plants are protected by people.

Just because a plant has beautiful flowers, it may have to be protected. So many people want to pick its flowers that there are not enough flowers left to make seeds.

If a plant does not make enough seeds, it is poorly protected. Very soon there will be few plants left because there are so few seeds made which might grow into new plants.

Many lovely wild flowers have been protected because they were beginning to die out. People have not picked these flowers for a while. Now more and more of these plants are growing in the woods and fields again.

Trees are also protected by people. We are careful with matches and campfires so that we do not burn down our beautiful forests.

Garden plants and crop plants are protected by people. These plants are carefully tended. The soil around the roots is loosened. The plants are sprayed to kill insects that might harm them. The plants are watered if it is necessary.

People may be a real protection for plants. But protection by people is only one of the many ways in which plants are protected.

## YOU MIGHT TRY THESE THINGS

1. You may want to be a member of a committee to find out more about how seeds grow in new places. You will need to get as many different seeds as possible. Take only one seed of each kind. Remember that we must protect our plants.

Try to find out how these seeds are moved to new places. Does the wind blow them? Do they float? Are they carried by animals?

2. Your committee may want to share some of the interesting information about seeds. You may want to do this by making an exhibit of your seeds. If the seeds are small, you might make packages for them of cellophane.

It is not necessary to find the name of each seed. You might arrange the seeds in groups with labels such as "Seeds That Fly," "Seeds That Float," "Seeds That Are Moved by Animals."

3. Another group in your class may be interested in understanding more about why and how we protect our forests.

4. Study the pictures of poison ivy and poison sumac on page 18 very carefully so that you will know these plants.

Find out if there are other stinging or poisonous plants in your neighborhood. Learn to know them so that you may protect yourself.

# Heat Causes Changes

# Heat and Volcanoes

Very few of us have ever seen a volcano erupting. But volcanoes are interesting to us just the same. Sometimes we read in our newspapers about a volcano erupting in some distant place. Sometimes we hear about such a volcano over the radio.

Heat has a great deal to do with the eruption of a volcano. If the rocks inside the earth did not become heated, there would be no eruption.

In some places below the earth's surface rocks become very, very hot. They become so hot that they melt. These hot, melted rocks bubble and boil and push their way upward and outward.

Sometimes the melted rocks flow out of the volcano. At other times the rocks become so very hot that the melted material pushes quickly upward.

Then there is a violent eruption!

Heat is important in causing a volcanic eruption. Heat is also important in many other ways. Let's think about some of the things that heat does.




## More Heat and Less Heat

"Ice to water to steam! Ice to water to steam!" This may sound like a magical saying. It really isn't. It is a way of saying that changes take place when heat is used.

You can do the experiment shown in the picture above. You will need an electric hot plate or a stove for your heat. You will also need a pan or a Pyrex dish and some ice.

If the weather is cold, you may get ice from out of doors. Or you might get some ice or ice cubes from a refrigerator.

If there is no refrigerator in your school, perhaps someone who lives near school will bring some ice cubes from home. The ice should be wrapped in several pieces of newspaper to keep it from melting too quickly.

Now place a pan of ice on the hot plate. Notice that the ice has already begun to melt.

Now turn on the electricity for your hot plate. The ice melts faster and faster. Before long all the ice has changed to water. Heat has brought this change about.

As the water gets hotter and hotter, you will notice tiny bubbles floating up to the top. These are air bubbles. Soon there are larger bubbles. These are steam bubbles. Now the water is boiling.

There is steam just above the boiling water, but it cannot be seen. It is very hot. Be careful not to get near it. Above the steam is a white cloud made up of water droplets.

Ice to water, water to steam. Ice to water to steam! This has happened because we used heat.

Now try making this experiment work backward. To do so, add a cool plate and a jar to your materials.

Remember that the white cloud is cool enough for you to pass your hand through it quickly. But it is not safe to pass your hand under the white cloud where the steam is. You will get a very bad burn if you do that.

Hold the plate about 8 inches above the white cloud. Do you see the drops of water on the plate? Turn the plate so that these drops can run off into the jar.

You may need to hold the plate above the white cloud of tiny water droplets several times in order to drain much water into the jar.

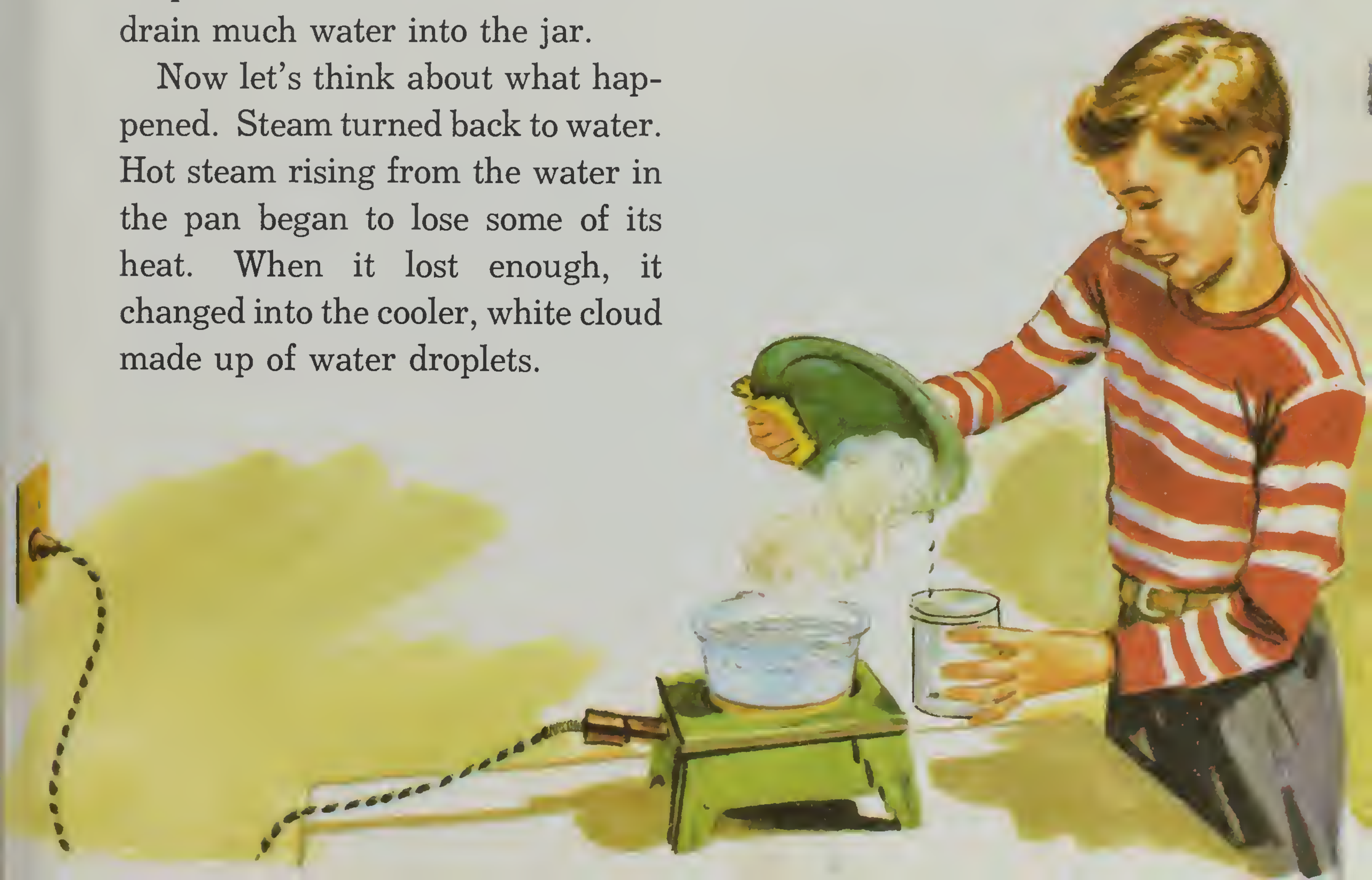
Now let's think about what happened. Steam turned back to water. Hot steam rising from the water in the pan began to lose some of its heat. When it lost enough, it changed into the cooler, white cloud made up of water droplets.

When the tiny water droplets touched the cool plate, they were cooled still more and became larger. What was once steam is now water in the jar.

You probably have some ideas about changing the water to ice. Here are two ways of doing it:

If it is quite cold outdoors, put the jar outside on the window sill and let the water freeze. If it is not cold enough outdoors to do this, put your jar in the coldest part of a refrigerator. Soon you will have ice.

Steam to water to ice! Steam to water to ice! This happened as the water became colder and colder.



# Liquids Go into the Air

It is not necessary to use much heat to cause water to go into the air. Try the following experiment:

Get two jars the same size and pour the same amount of water in each. Put one jar near the radiator or in a sunny window. Put the other jar in the coolest spot in the room, but not in a closet or cupboard.

After two days measure the amount of water that is left in each jar. Is there less water in the jar that was in the warmer place?

Some of the water from the cooler jar went into the air, too. There was enough heat to cause some water from both jars to evaporate, or go into the air.

When any liquid, such as water, evaporates, it changes into a gas. Steam is water which is in the form of a gas.

Water is always in the air in the form of a gas called water vapor. Water vapor is invisible.

At the bottom of the page you will find a list of gases. Like water vapor, many gases are invisible. Perhaps that is why we do not often think about gases.

Liquid alcohol will turn into a gas very easily. If you put a tablespoonful of rubbing alcohol in a saucer, it will evaporate quickly. It has changed into a gas. It has evaporated.

| Solids | Liquids | Gases |
|---|---|---|
| Ice | Rubbing alcohol | Helium |
| Stone | Grape juice | Water vapor |
| Rubber | Milk | Oxygen |
| Silver | Oil | Carbon dioxide |
| Iron | Water | Nitrogen |


Liquids evaporate when they are heated. The heat that warms the liquid may be from fire or from warm air or even from your warm skin.

When warm air heats water, the air becomes cooler, and the water is warmed. If warm skin heats water, the skin becomes cooler, and the water is warmed.

You can see how this happens for yourself. Wet some cotton with water and touch your skin with the cotton. After a while the wet place on your skin will be dry because the water has evaporated.

Do you notice that your skin now feels a little cooler? Heat left your skin and turned the water into water vapor. We say the water has evaporated.

Some liquids evaporate more quickly than others. Try the next experiment to help you to understand that this is so.

Put out both your hands. Ask one of your friends to wet one piece of cotton with water and another piece with rubbing alcohol.

Have your friend touch one piece of cotton to the back of one of your hands. Have him touch the other piece to the back of the other hand.

How cool the hand touched with rubbing alcohol feels! The alcohol uses heat from your hand faster than the water does.

Or we can say this another way. The skin covered with alcohol loses heat more quickly; so it feels cooler than the skin covered with water.

When heated enough, liquids change into gases. In order to change, some liquids need more heat than others do.

You have seen that liquids can change into gases. You also know that water in the form of a gas in the air can change back into water as a liquid.

You know, too, that water can become solid. Then it is ice. Ice can be changed back into liquid water by melting.

Other solids can change to liquids, too. Remember how the tar on a street gets sticky on a hot day? The solid tar is changing to a liquid.

If you have ever made lead soldiers, you have seen a solid changed to a liquid. When you made lead soldiers, the solid lead was heated until it was a liquid.

Then the liquid lead was poured into molds. As the liquid lead cooled, or lost heat, it changed back into a solid.

It is interesting to think of the things around us as gases or solids or liquids. It is fun to think of the ways that they may change.

## Taking Up More or Less Space

Thermometers are very useful to us. They tell us the temperature of the air in our rooms or out of doors. They may be used to see whether or not we have a fever. Mother may use one when she makes candy.

The thermometers that we use most often have liquid in them. If the liquid is red, it is alcohol that has been colored. If the liquid is silvery, it is mercury. Mercury is quicksilver.




We might try to find out what happens when the alcohol or mercury in a thermometer moves up or down.

First, hold your thermometer up in the air, being sure to hold it at the top. Think of why it should be held at the top and not at the bottom. Now read the temperature.

In the picture the room temperature is 68 degrees. The temperature in your room may be more, or it may be less. Write down your room temperature.

Next you will need a pan of warm water. The water should not be too warm—just warm enough so that it feels comfortable to your fingers.

Now put the lower end of the thermometer into the water. Does the liquid in the thermometer move upward? Perhaps the temperature is now 74 degrees, or it might be 82 degrees.

Don't forget to write down the temperature of the water. You will need to know this later.

When the alcohol in the thermometer tube was warmed, it took up more space. Another way to say this is to say that the alcohol has expanded. The only place it can go is up the tube.

For the last part of your experiment you will need a pan of cold water. If you have some ice, put it in the water.

Put the lower part of your thermometer in the pan of cold water. Watch the alcohol again. It moves downward. The alcohol now takes up less space. Perhaps your thermometer now reads 45 or 39 or 34 degrees.

Alcohol is a liquid. When it is heated, it expands, or takes up more space. When it is cooled, it contracts, or takes up less space.

# More about Expanding and Contracting

Here are two more experiments that will help you to understand more about expanding and contracting:

First, you may need to make a wooden stand like the one you see in the picture below. You may not need to make the stand if you have a hook in your room from which you could hang a wire.

The other things you will need for this experiment are a candle, some straight copper or iron wire with no kinks in it, and a stone. The stone should weigh about one-half pound.

Fasten one end of the wire around the stone. Now fasten the other end of the wire to the wooden stand as is shown in the picture below. Let the wire be long enough so that the stone just misses the bottom of the stand as it swings back and forth.

Now you are ready to use the candle. Before you light the candle, be sure there is a pan of water on the table. Why is this a good thing to do?

Warm the wire with the candle flame. After a while you will notice that you cannot swing the stone back and forth easily. Later the stone will touch the bottom of the stand. You cannot swing the stone back and forth.

The wire expanded when it was heated. It now takes up more space.

Let the wire cool. When it has cooled, the stone should again swing back and forth freely. The reason is that the wire now takes up less space. Or we could say the wire contracted when it became cool.

Copper wire and iron wire are solids. These solids expand when they are heated and contract when they are cooled.

The next experiment may help you to understand that gases also expand when they are heated. They too contract when they are cooled.

For this experiment you will need a balloon, some thread, and a measuring tape. You will also need a warm, sunny window.

Blow up the balloon just enough to make it nice and round. Wind some thread around the end of the balloon several times. Tie the thread tightly so that no air will leak out.

Use the measuring tape to find how large your balloon is. Is it 20 inches round? Whatever its size, be sure to write down the number of inches. Now hang the balloon in the warm, sunny window.

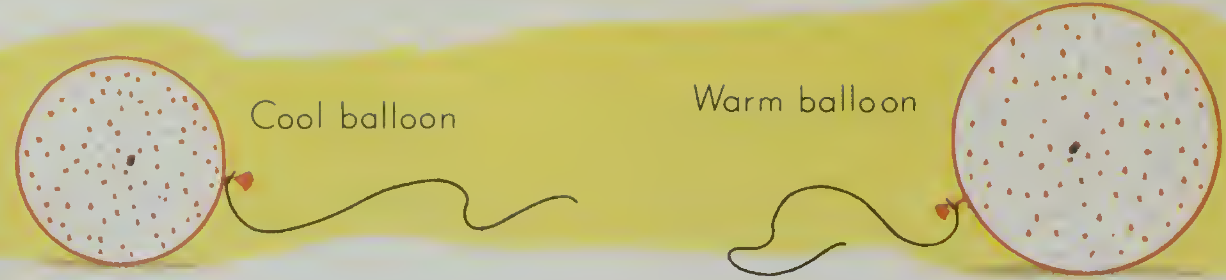
After about 30 minutes measure the balloon again. It should be a little larger now. It may be as much as 22 inches round. If the balloon is smaller, some of the air has leaked out, and you will have to start over again.

Why did the balloon expand? The air you blew into the balloon is made of several gases. Gases expand when they are heated.

Gases contract when they are cooled. Check this by putting your balloon in a cool place and measuring it again.

Now think again about water turning to steam. When water turns to steam, it takes up more room. Steam is a hot gas. It is expanding.

Steam expands just as the air in the balloon expanded. That is why steam rushes out of the kettle when water is boiling. The steam is taking up more room. You have learned that gases expand when they are heated.




# Why Things Expand and Contract

Things expand and contract. We have learned that this is true of water, gases, wire, and other things. Now let's try to understand why things expand and contract.

Look at the two balloons at the top of the page. There are exactly the same number of dots in each balloon. Each of these dots stands for a tiny particle of gas.

Of course there are many, many, many more tiny particles of gas in the balloons than the picture shows. It would be impossible to make dots for the thousands and thousands of particles of gas in one balloon full of air. And it would be impossible for you to make dots as small as the tiny particles of gas really are.

You might like to know the real name for these particles of gas. Each particle is called a molecule. The molecules of one kind of gas may be larger than the molecules of another kind.

Air is made of molecules of different kinds of gases. The dots in the balloons are of different colors to show that there are different gases in the air.

Molecules are all around us. Everything we know about is made up of molecules. Water is made of molecules. Stones are made of molecules. Plants are made of molecules. We are made of molecules.

Here is another interesting fact about molecules: All of them are moving all the time. They move back and forth, back and forth.

Sometimes molecules move back and forth faster than they do at other times. This happens when they are heated.

The molecules move back and forth faster and faster. They bump into each other more and more. So they push each other apart. When they cool, the molecules slow down and do not take up so much space.

# Heat Travels

When you put your hand near a hot radiator, your hand feels very warm. As you move away from the radiator, your hand feels cooler, but it is not cold.

The radiator first warms the air near it. As this warmed air expands, or grows larger, it moves about.

Have you ever tried an experiment like the one shown on this page? The girl is putting a few tiny feathers in the air over the radiator. You could also use milkweed seeds or small pieces of tissue paper.

As the warmed air expands and moves upward, it takes the feathers with it. The feathers show us that warmed air moves about the room.

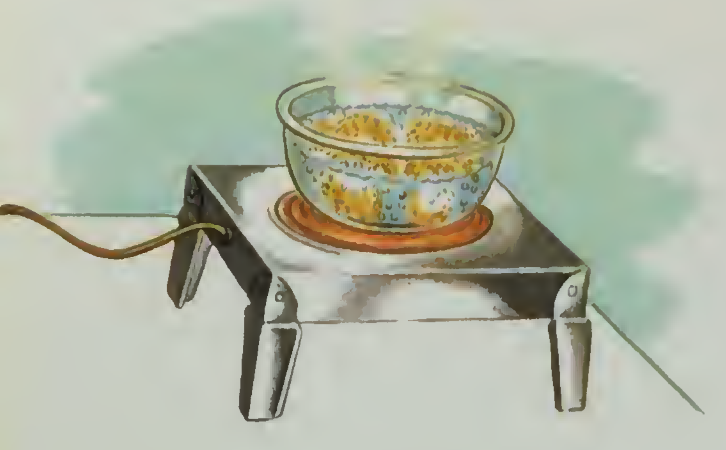
If sunlight comes into your room through a window over a radiator, you may have noticed something else. You may have noticed small pieces of dust being carried upward with the warmed air.

When the warmed air reaches the top of the room, it will begin to cool. As it gets cooler, the air will contract more and more. It then moves downward and along the floor.

When the air reaches the radiator again, it will begin to grow warm. It expands as it is heated and moves upward again. So after a while the whole room becomes warm.

You might try taking the temperature of the air in your room to see where it is warmest. Hold a thermometer in the warm air over the radiator. Be sure to hold the thermometer by the top. You will want to record the temperature.

Now stand on a chair in the center of the room. Hold the thermometer as high as you can and take the temperature. Do you see that heat travels upward?



Heated air can travel about. So can heated water.

The next experiments help to show that heated water moves. For the first experiment you will need an electric hot plate or a gas stove. You will also need a pan or Pyrex cooking dish, water, and about two tablespoonfuls of sawdust.

Fill the pan or Pyrex cooking dish almost full of water. Now put the sawdust in the water. Let the sawdust settle down to the bottom of the pan.

Next turn on the heat. As the water becomes warm, you will notice that the sawdust begins to move. Watch carefully to see which part moves first.

Usually the sawdust in the center of the pan will begin to move first. When it does, the water in the center of the pan has become warm first.

When the water becomes warm, it expands and moves upward, carrying the sawdust with it. Then, as it heats, the water travels near the surface toward the sides of the pan, then down the sides of the pan. The sawdust is carried right along with the water.

You have really caused a current to be formed in the water. Warmed water moving upward and cooler water moving downward cause the current.

As the water gets hotter and hotter, it moves faster and faster. The sawdust moves faster and faster, too. After a while all the water in the pan will be very hot. Boiling hot, we say. When this happens, the sawdust will be moving about in all directions.

You might like to try another experiment which shows that heated water moves about.

You will need a deep glass dish or a pail, and an ink bottle with a steady base. You will also need a cork or a screw cap for the ink bottle and a cup of warm water. The water should feel warm to your hand. You will also need some cake coloring or water paint or ink.

Fill the deep glass dish with cold water. Put some of the coloring material into the ink bottle. Now fill the bottle with warm water and cork it.

Then lower the bottle into the dish, putting the bottle in the center. Do this carefully so that the water in the glass dish is disturbed as little as possible. Now lift the cork out of the bottle. As you take your hand out of the dish, try not to disturb the water.

Watch the colored water. It begins to move out of the bottle and up to the top of the cold water.

Does this help you to understand better that warm water expands and moves upward? As the warm colored water cools, it begins to move downward in the glass dish.

Soon the colored water will mix with the clear water. They mix when the clear water becomes warmer and the colored water becomes cooler. After a while all the water in the dish will be about the same temperature. When this happens, it is hard to see that the water is still moving about. It is moving, but it is not moving quite so fast.

Now let us see what is happening that causes water to move about as it is heated.

Do you remember why air moves about when it is heated?

We found that when the molecules that form the air get hotter and hotter, they move faster and faster. As they move faster, they bump into each other more often. They push each other aside. Or we could say that air expands when it is heated. The molecules of the air move faster, the more they are heated.

Water is made of molecules. The very smallest particle of water is a water molecule.

As water molecules grow hotter and hotter, they too move faster and faster. This makes them bump into one another more and more. They push one another apart. So the water expands in the same way that air expands.


# Heat Travels in Solids

Do you like to toast marshmallows or wieners? It's fun! Isn't it? Most of us look around for a straight, green stick to use for roasting our wieners and marshmallows.

We use a green stick for two reasons. First, it does not burn easily. Second, our hands do not become warm from the stick.

Once some children who had had trouble with their marshmallow sticks catching on fire decided to use a metal rod instead. They soon found that this did not work at all well. The rod became so hot that they could not hold it.

The boy in the picture at the top of this page is doing an experiment which shows that heat travels through metal.

Perhaps you would like to try the same experiment. Look at the picture and make a list of the things you will need.

Now check your list with this list: a pan of water for safety, matches, a candle in a saucer, a steel knitting needle, small pieces of candle wax or paraffin, and a cork.

The cork on the end of the steel knitting needle will keep your fingers from becoming too warm. You could use a pot-holder for this instead of the cork.

Put three tiny pieces of wax on the knitting needle. Hold the end of the needle in the candle flame.

After a while the piece of wax nearest the flame will drop off. Then the one next to that will drop off and then the next.

This experiment helps us to see that heat travels through steel. The part of the needle in the flame got hot first, and then the part next to that got hot. Finally, the whole knitting needle was hot.

The reason that this happened is that molecules move. Steel, just as everything else, is made of molecules. As the steel molecules are heated, they move faster and faster.

When the first molecules begin to move faster, they bump into the molecules next to them. Now these molecules move faster. Soon all the molecules which make up the steel knitting needle move much faster than they did at first.

When this is happening, we say that the knitting needle is hot. When the knitting needle is cool, its molecules are not moving so fast.

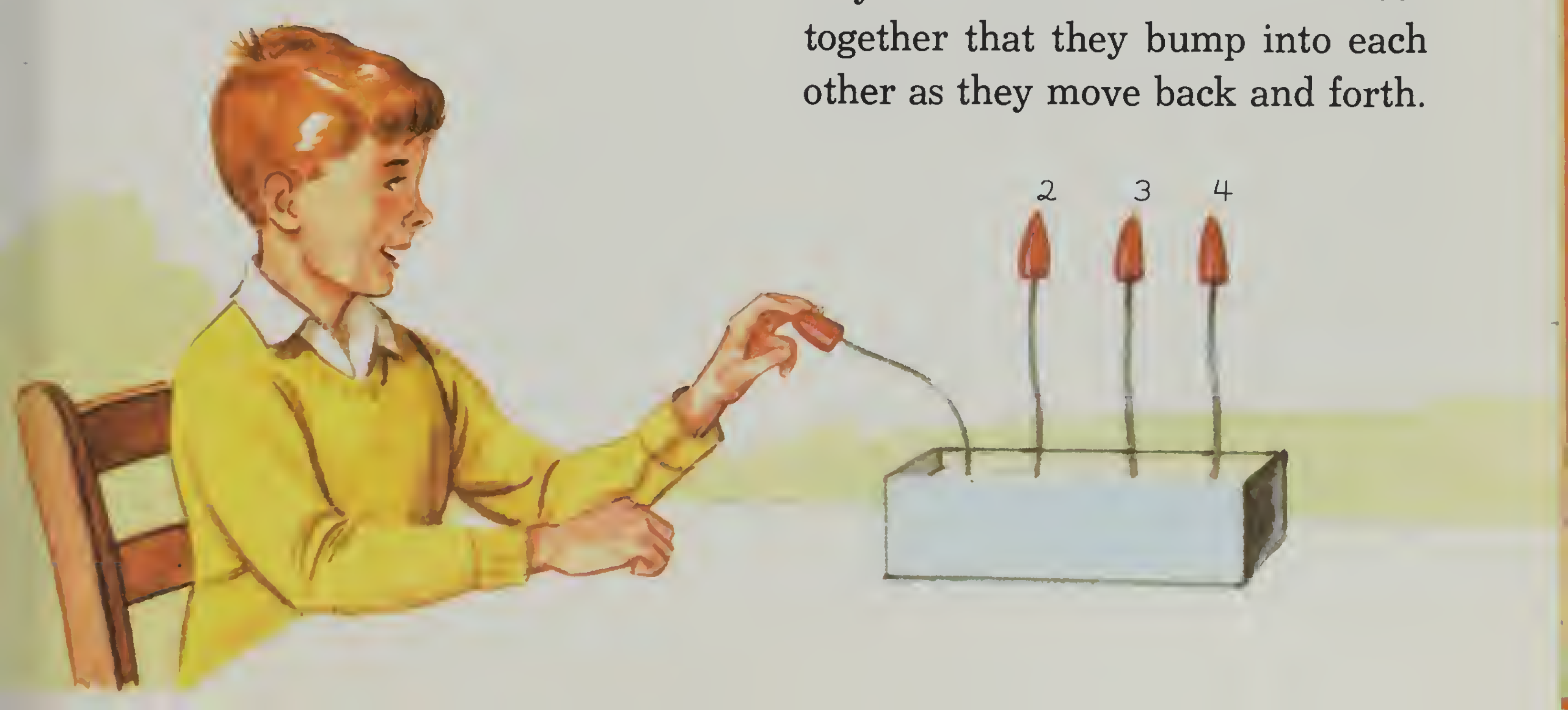
The picture at the bottom of the page may make this idea clearer. You might want to try the experiment shown in the picture for yourself.

An old shoe box was filled with plaster of Paris. Just before the plaster of Paris hardened, four shoe trees were set up in it.

Then the box with the shoe trees was set aside for a day to be sure that the plaster was hard.

The boy is pulling one shoe tree toward himself. When he lets go of it, shoe tree number 1 will move back and forth. Number 1 will hit number 2, and it will move back and forth. Then number 3 will move back and forth. Finally, number 4 will move back and forth.

In solids heat travels from molecule to molecule in much this same way. The molecules are so close together that they bump into each other as they move back and forth.



# Water out of Doors

Heating and cooling affect water out of doors. It is heating and cooling which help to cause rain, snow, sleet, hail, frost, and dew.

Rain is water that has become cooled in the air. You know that water evaporates from puddles, lakes, streams, wet soil, and other places. You also know that water turns into a gas. Water that has become gas is called water vapor.

You cannot see water vapor. It is all around you now in this room, but you cannot see it. As you take air into your lungs, water vapor goes into your lungs also. As air leaves your lungs, so does water vapor. Water vapor is one of the invisible gases in the air.

If water vapor becomes cool enough, it condenses and forms water droplets. You discovered this if you did the experiment on page 27. If you have not done that experiment, you might try it now.

When warm air out of doors moves upward, the water vapor in it moves upward, too. As the water vapor is carried higher and higher, it gets cooler and cooler.

Finally, the water vapor will begin to form droplets of water. When a great many of these tiny water droplets gather together, we are able to see them. Such a mass of water droplets is called a cloud.

If the water droplets grow too heavy to float in the air, they fall down on the land and lakes and oceans. Then we say it is raining.

Sleet falls from the air, too. Sleet begins as raindrops or as partly melted snow. If the rain or snow falls through very cold air, it freezes as it falls. We could say that sleet is frozen rain.

Warm and cold air can affect water in another way and form hail. Those of you who have seen hailstones know that they are hard and icy.

Hailstones form when the air in the lower part of a cloud is warm, and the temperature of the air in the colder, upper part of the cloud is below 32 degrees. As you know, water will freeze at this temperature. Because of the cold and the warm layers of air, there are strong wind currents in the cloud.


Water droplets are formed in the lower, warmer part of the cloud. Then they are carried upward by the expanding, warmer air.

Now the water droplets are in a layer of colder air. Here they freeze. Then they are carried downward by the downward-moving air.

Again they are in warmer air. Moisture collects on the small, frozen droplets. Once more they are carried upward by upward-moving air. The moisture on the outside of each icy droplet freezes. This forms a tiny hailstone.

The small hailstones may be tossed up and down within the cloud many times. Each time, a very thin layer of ice forms on the outside of the hailstone. Each hailstone becomes heavier and heavier as it collects more water which turns to ice.

Finally, the hailstones become so heavy that they fall to the ground.

Rain, snow, sleet, and hail are water that has gone up into the air and changed into another form.

Dew and frost are also forms of water. Dew does not fall, but it comes out of the air. Here is an experiment that may help you to understand this:

Fill a glass about half full of ice. Now pour water into the glass. Do you notice drops of water forming on the outside of the glass? This water is dew. It came out of the air.

When water vapor in the air is cooled, it condenses to form droplets of water. Early in the morning this may happen outdoors. The air contains water vapor. When warmer water vapor touches cooler grass or trees, it condenses and forms dew.

Frost is formed in much the same way as dew. The only difference is that the grass and trees are so cold that the water vapor freezes when it touches them. Instead of water droplets, tiny crystals of ice are formed from the water vapor. These ice crystals are called frost.

Snow is solid water falling from the air. Snow comes out of the air in much the same way that rain comes out of the air.

When it snows, the air above the ground is very cold. Warmer air with its warmer water vapor moves upward into the cold air. As the water vapor condenses in the cold air, ice particles are formed.

Each tiny particle of frozen water is a snow crystal, much like the ones you see above. Perhaps you will be able to see snow crystals if you catch some of them on a piece of dark cloth.

## Freezing and Thawing

"Whew! It's freezing cold today!" This usually means that it is so cold that water will turn to ice. Almost always when we think of freezing and thawing, we are thinking about water.

But other things freeze and thaw, too. Look about you right now and try to discover some things in this room that are frozen.

Are there any pieces of metal in the room? Is there a radiator? Are any of the chair legs made of metal? What about your pen point? Are any of these things very cold?

Yes, all these pieces of metal are frozen. Some things can be much warmer than water is and still be frozen. This is certainly true of the metal objects that have been named.

Just what is really meant by freezing? It simply means that the molecules in a substance have slowed down until they do not move from place to place within the substance.

The molecules have not stopped moving entirely. Even in a piece of ice or in a piece of frozen metal the molecules are moving back and forth. But they are not moving from place to place, as they do when the ice or metal is in a liquid form.

You know that iron or lead can be melted. To melt these materials, heat must be used. Their molecules will then move faster and faster.

When the molecules finally move from place to place within the material, the iron or lead has melted.

Some materials do not freeze until they become very, very cold. Alcohol and mercury are two of these materials. Both alcohol and mercury will freeze. But before they freeze, they must be much, much colder than freezing water.

Do freezing and melting have new meanings for you now? When things freeze, their molecules slow down, but they still move back and forth. When things thaw, their molecules speed up and also move from place to place.

## THIS IS FOR YOU

1. How does heat cause changes in our food? Make a list of good and bad changes caused by heat.

2. Concrete sidewalks are divided to allow the concrete to expand in hot weather. If the cracks are not large enough, the walk will buckle and break. Why?

3. Is there an iron foundry or a blacksmith shop in your neighborhood? Plan to visit it and see how iron is heated and even melted.

4. Why does smoke rise?

5. Heat travels through some things faster than through others. Here is an experiment to show this:

You will need a pan of very hot water. You will also need two or three spoons of the same size, but of different materials. The spoons might be made of wood, tin, and aluminum. Put the bowls of the spoons in the water. Which handle gets hot first? Why?

# The Weather Today and Tomorrow

# Fair Days and Cloudy Days

What fun it is to have a picnic! When a picnic is planned, we always hope for a beautiful, sunny day. We listen to the weather report the day before. We listen to the weather report before we go to school.

Even though the weather-reporter is often right, he cannot always predict the weather correctly. This may be true on a warm summer day during the last weeks of school. It is sometimes hard to know at that time of the year whether there will be a thunderstorm.

These children and their teacher have almost finished their picnic. It is a good thing because the tall clouds mean that there may be rain very soon. They know that the tall clouds with the broad bases are thunderheads. Thunderheads sometimes appear on a sunny, hot summer afternoon.

The weather changes from day to day. The weather even changes from hour to hour. There are fair days, cloudy days, snowy days, and rainy days. There are hot days and cold days.



# Keeping Weather Records

If we want to learn more about weather changes, we shall need to keep weather records. To keep weather records, we must learn to watch the weather and to use weather instruments.

Let us think of some things we will need to put into our records. We will want to keep a record of sunny days, rainy days, and cloudy days. We will want to keep a record of the temperature out of doors. We will want to keep a record of the speed of the wind. A record of the direction of the wind will be important, too.

If we have a barometer like the one shown on the table, it will be of help in studying the weather. A barometer is an instrument that helps us to know what the weather will be like from day to day.

A barometer is not necessary, however. There is really only one instrument that is needed for our weather records. That instrument is a thermometer.

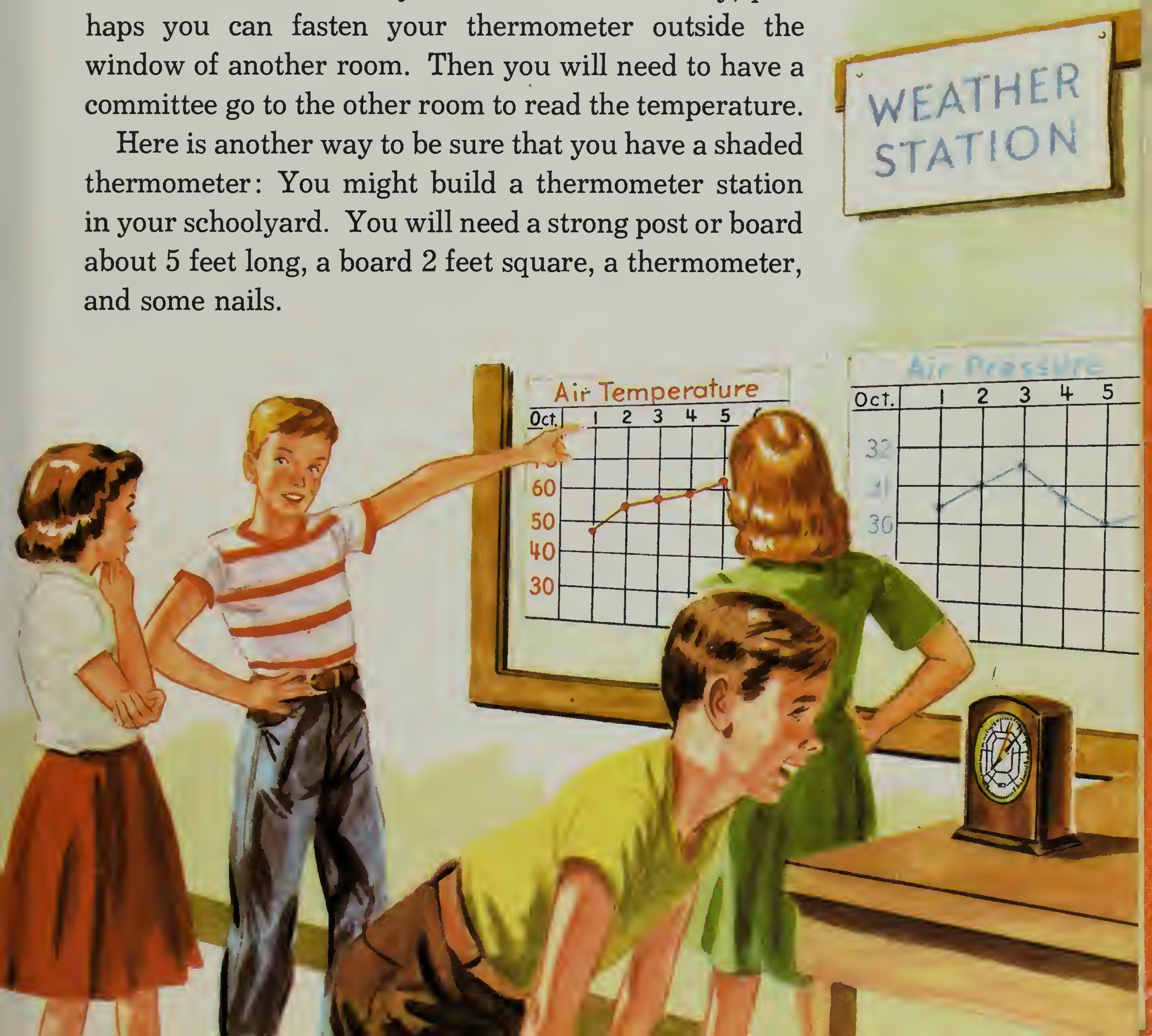


An alcohol thermometer will be the best kind to use, since red alcohol can be seen more easily than silver mercury. So it is often easier to make a true reading from an alcohol thermometer.

The temperature needed for your weather record is the temperature out of doors. Your thermometer should be placed outside a window. Be sure that the sun never shines on your thermometer. For your record you will need the temperature of the air in a shady place.

If all the windows in your classroom are sunny, perhaps you can fasten your thermometer outside the window of another room. Then you will need to have a committee go to the other room to read the temperature.

Here is another way to be sure that you have a shaded thermometer: You might build a thermometer station in your schoolyard. You will need a strong post or board about 5 feet long, a board 2 feet square, a thermometer, and some nails.



First, the post should be driven into the ground. You may need to ask a father of one of the children in your group to help you do this. Or you might ask the custodian or the principal to help.

Next nail the board to the top of the post as you see in the picture. Then fasten the thermometer securely to the post about 4 inches below the board.

Now you have a shaded thermometer. When you read this or any other thermometer, be sure your eyes are level with the top of the red alcohol or silver mercury. If they are, you will probably be able to make a more accurate reading. Can you tell why?

Knowing about the air is very important when you keep weather records. This is important because weather might be thought of as changes that take place in the air. Change in the temperature of the air is only one of these changes.

Another change to watch for is a change in the direction of the air movement. You cannot see this, of course, since air cannot be seen. But you can find out about air movement by knowing in which direction the air is moving.

Wind is moving air. We speak of a north wind or a south wind or a west wind or an east wind. When we do, we are talking about the direction of moving air.

If you are to be able to tell the direction from which the wind is blowing, you will need to know where north is, where south is, where east is, and where west is.

You know that the sun rises in the east. It sets in the west. But do you know where north is?

Here is a way to check yourself: Stand up and face east. Now raise your left arm so that it is pointing away from your body. Your left hand is pointing to the north.

Now raise your right arm in the same way. It is pointing south.

Now you will find it easy to tell the direction of the wind. Watch a flag on a pole in an open space. Or watch a flag on top of a tall building.

A flag will blow with the wind. A north wind will blow a flag away from the pole toward the south. A west wind will blow a flag toward the east.

A wind is always named after the direction from which it is blowing. An east wind blows from the east. A south wind blows from the south.

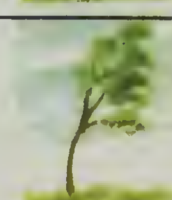
Another thing to keep is a record of the changes in the speed of the wind. Do this by watching the trees as they are blown by the wind.

To find out about the speed of the wind, watch some trees very carefully and compare their movement with the chart below.

If your school is in a very large city, you may want to notice the trees in a park. Make a copy of this wind chart. Then, as you are walking to school, notice the trees.

It is always a good thing to check your idea of wind speed with at least one other person. Then you will have a more accurate record.

## A Wind Scale

| | MILES PER HOUR | TYPE OF WIND | |
|---|---|---|---|
| 1. Smoke rises straight up; leaves still | Less than 1 | Calm |  |
| 2. Leaves on trees barely rustle | 2–7 | Slight breeze | |
| 3. Leaves and twigs in motion; flags snapping | 8–12 | Gentle breeze |  |
| 4. Dust and loose papers flying; small branches swaying | 13–18 | Moderate breeze | |
| 5. Small trees in leaf swaying; crests appearing on waves | 19–24 | Fresh breeze | |
| 6. Larger branches in motion; whistling heard in telegraph wires; hard to walk with open umbrella | 25–31 | Strong wind |  |
| 7. Whole trees swaying; hard to walk against wind | 32–38 | High wind | |
| 8. Twigs broken off branches | 39–46 | Gale | |
| 9. Branches of trees broken; signs torn down; chimneys blown down | 47–54 | Strong gale |  |
| 10. Trees uprooted; barn roofs torn off; buildings damaged | 55–75 | Whole gale | |
| 11. Buildings destroyed; trains overturned; telephone poles snapped off; automobiles lifted off the highways | Above 75 | Hurricane | |

Another weather instrument you may need to know about is the barometer. On the left in the picture above is an aneroid barometer. On the right is a barometer sometimes called a Cape Cod barometer.

The aneroid barometer is more accurate than the Cape Cod barometer. Someone in your room may have an aneroid barometer at home. If so, perhaps that child could read the barometer each morning and report to your group. Or you might be able to borrow an aneroid barometer to use in your room. Remember to be very careful of it.

The black pointer on the aneroid barometer moves to the right or to the left as the weather changes. Whenever the barometer is read, the short second pointer can be moved by hand to that place to mark the reading.

When you look at the barometer several hours after your last reading, the black needle may have moved. The markings on the barometer help you to know what the changes in the weather will be.

Usually, if the black pointer moves to the right, the weather will be clearer in about twenty-four hours. If the black pointer moves to the left, it may become cloudy, or there may be rain or snow.

The Cape Cod barometer is not as accurate as the aneroid barometer. But it helps us to understand about the weather, especially if it is kept in a room with a steady temperature.

The red liquid in the Cape Cod barometer is colored water. In order to tell what the weather is going to be, we must watch the height of the water in the spout.

If the water in the spout falls, it usually means that the weather will be clear. If the water in the spout rises, the weather may be cloudy or rainy during the next day or so.

Sometimes the water in the spout rises so high that it drips out. This often means that the weather soon will be stormy.

Both these barometers show changes in the pressure, or weight, of the air. When air pressure becomes greater, the weather is usually clear or clearing. When air pressure becomes less, the weather is usually becoming less settled.

Men and women who work out the weather reports that we read in the newspaper or hear over the radio use very accurate barometers. Their barometers are mercury barometers.

Now you have enough information to begin keeping records. Your first weather record might be a record kept for only one day.

The chart below shows one way that such a record might be kept. You may want to keep your record in some other way.

Here are some things to remember as you keep your record: Put down the times at which you take readings. Read the thermometer carefully. Keep your eyes level with the top of the liquid in the tube.

Ask at least one other person to check with you the wind direction and wind speed. Notice whether the sky is cloudy or sunny.

Now look at your record. Does it show any changes in the weather during the whole day or from hour to hour?

| Weather for October 6 | | | | |
|---|---|---|---|---|
| | 9 A.M. | 11 A.M. | 1 P.M. | 3 P.M. |
| Air temperature | 61° | 64° | 62° | 59° |
| Wind direction | E | NE | NE | NE |
| Wind speed | Fresh | Moderate | Moderate | Moderate |
| Sky condition | Partly cloudy | Cloudy | Cloudy | Cloudy |
| Rain or snow | None | None | Rain | Rain |

| Weather Record at 10 A.M., October 16-22 | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Oct. 16 | Oct. 17 | Oct. 18 | Oct. 19 | Oct. 20 | Oct. 21 | Oct. 22 |
| Air temperature | 42° | 51° | 55° | 51° | 41° | 38° | 40° |
| Wind direction | NW | W | S | SE | E | NE | NW |
| Wind speed | Strong | Fresh | Moderate | Gentle | Moderate | Strong | High |
| Sky condition | Partly cloudy | Clear | Clear | Partly cloudy | Cloudy | Cloudy | Cloudy |
| Rain or snow | None | None | None | None | Rain | Rain | None |

## Keeping Weekly Weather Records

One group of children decided that they would like to keep another kind of weather record. They wanted to find out how much the weather changed from day to day.

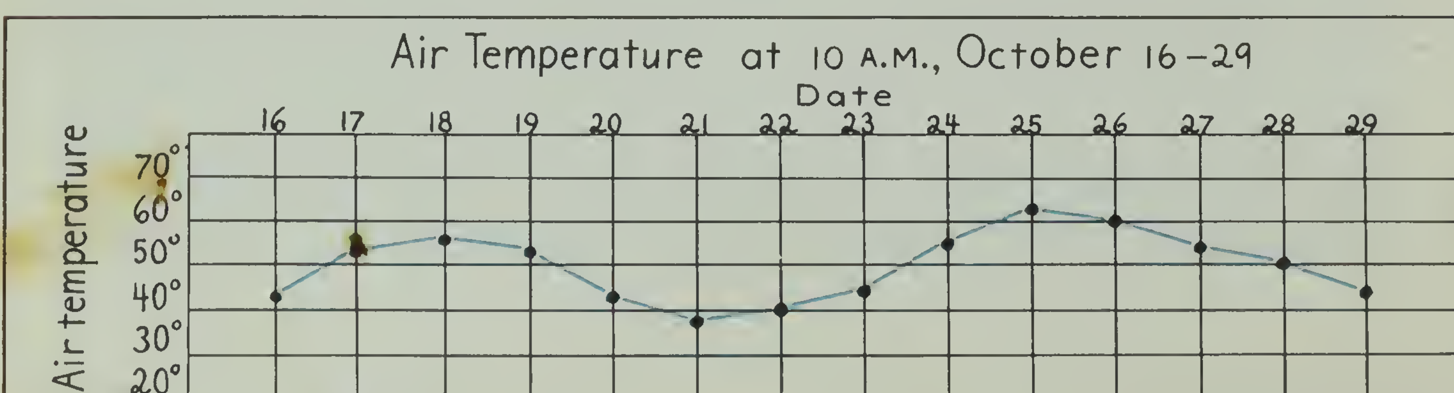
These children decided to watch the weather for two weeks. They were careful to make accurate readings and observations. They were sure to have at least two children work on each observation.

In order to be able to compare the weather from one day to the next, they made observations at the same hour each day.

They chose ten o'clock in the morning as their observation time. But they might have chosen nine o'clock or two o'clock. Any hour would have been a good time, so long as they observed the weather at the same hour each day.

At first the group thought the record could be kept only during the school days of the week. Then they remembered that two of the children lived near the school. These children were able to be weather-observers on Saturday and Sunday.





| Weather Record at 10 A.M., October 23-29 | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Oct. 23 | Oct. 24 | Oct. 25 | Oct. 26 | Oct. 27 | Oct. 28 | Oct. 29 |
| Air temperature | 43° | 55° | 62° | 60° | 54° | 50° | 44° |
| Wind direction | NW | W | SW | SE | E | S | W |
| Wind speed | Strong | Moderate | Moderate | Moderate | Gentle | Fresh | Strong |
| Sky condition | Partly cloudy | Clear | Clear | Partly cloudy | Cloudy | Cloudy | Partly cloudy |
| Rain or snow | None | None | None | None | Rain | Rain | None |

Other children in the group decided to keep air-temperature and wind-speed records in another way. They decided to use graphs.

At the bottoms of these two pages are the graphs which they kept. The numbers on the left side of the air-temperature chart are temperature readings. A dot was put on the line for each day opposite the correct air temperature. Then the dots were connected by a line.

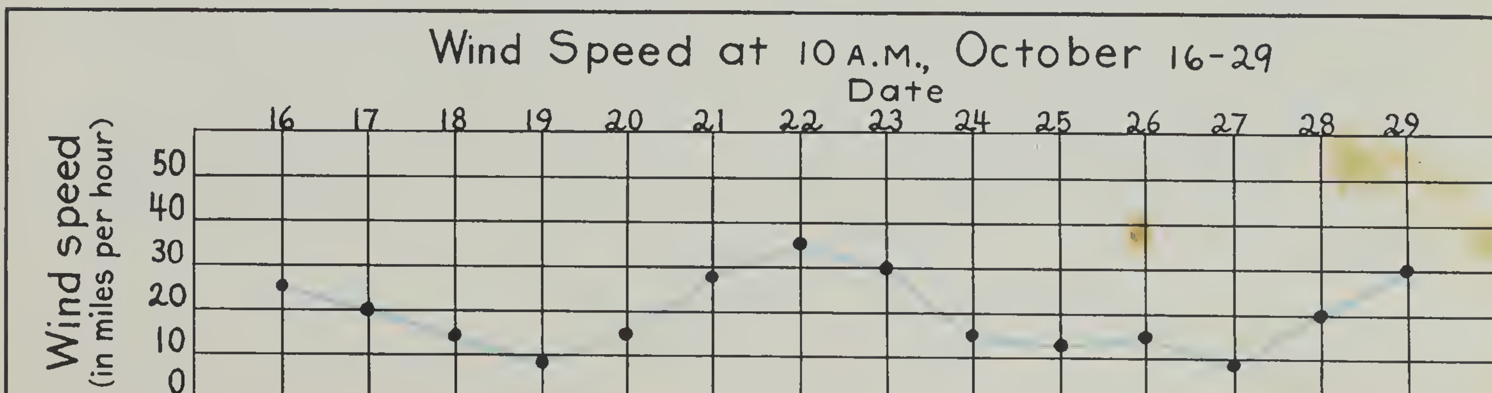
The speed of the wind was recorded each day on the wind-speed chart. A graph was made by connecting the dots showing the wind speed for each day.

During the days that the weather records were being kept, the children studied their charts and graphs. These are some of the things they discovered by the end of their study:

Air temperature changes from day to day. Wind speed changes, too. Sometimes the wind speed is almost the same for two days. Wind direction may not change for a day or two, but it usually changes from day to day. The way the sky looks also changes from day to day.

The children decided that all these changes in the condition of the air make up the weather.





| Weather Record for Victoria, British Columbia | | | | | |
|---|---|---|---|---|---|
| | Air Temperature | Wind Direction | Wind Speed | Sky Condition | Rain or Snow |
| Oct. 24 | 42° | S | Gentle | Foggy | None |
| Oct. 25 | 41° | SE | Gentle | Foggy | Drizzle |
| Oct. 26 | 45° | SE | Gentle | Foggy | Drizzle |
| Oct. 27 | 46° | SE | Gentle | Cloudy | Rain |
| Oct. 28 | 61° | SW | Moderate | Cloudy | Rain |
| Feb. 13 | 40° | SE | Fresh | Cloudy | Rain |
| Feb. 14 | 41° | SE | Moderate | Cloudy | None |
| Feb. 15 | 42° | SE | Moderate | Partly cloudy | None |
| Feb. 16 | 42° | E | Gentle | Cloudy | Drizzle |
| Feb. 17 | 40° | SE | Fresh | Cloudy | None |
| May 8 | 41° | NW | Gentle | Partly cloudy | None |
| May 9 | 46° | NW | Gentle | Cloudy | None |
| May 10 | 47° | N | Gentle | Partly cloudy | None |
| May 11 | 49° | — | Calm | Clear | None |
| May 12 | 52° | NW | Gentle | Partly cloudy | None |

## Weather through the Year

On these pages are weather records from a city in British Columbia and a city in Ontario. Each record covers five days. They were taken during three different months, October, February, and May.

Look at the October records for both places. You will see that the temperature changes from day to day in both places. Is this also true of the wind speed and the wind direction?

Now look at the record of rainy, cloudy, and sunny days in these two places. Notice how the sky conditions change.

The weather records for February in British Columbia and Ontario are interesting, too. Notice that the temperature changes from day to day, just as it did in October.

Some February days in each place are warmer than other February days.

## Weather Record for Windsor, Ontario

| | Air Temperature | Wind Direction | Wind Speed | Sky Condition | Rain or Snow |
|---|---|---|---|---|---|
| Oct. 24 | 38° | NW | Fresh | Clear | None |
| Oct. 25 | 40° | SE | Moderate | Cloudy | Drizzle |
| Oct. 26 | 38° | W | Moderate | Clear | None |
| Oct. 27 | 42° | S | Moderate | Clear | None |
| Oct. 28 | 50° | SW | Moderate | Clear | None |
| Feb. 13 | 28° | NE | Strong | Cloudy | Snow |
| Feb. 14 | 33° | NE | Moderate | Cloudy | Snow |
| Feb. 15 | 30° | SW | Moderate | Cloudy | Light snow |
| Feb. 16 | 26° | W | Moderate | Cloudy | Light snow |
| Feb. 17 | 28° | NW | Fresh | Partly cloudy | None |
| May 8 | 45° | SE | Moderate | Clear | None |
| May 9 | 58° | SE | Strong | Cloudy | Rain |
| May 10 | 52° | SW | Fresh | Clear | None |
| May 11 | 50° | SW | Fresh | Partly cloudy | None |
| May 12 | 59° | NW | Moderate | Clear | None |

You may have noticed another thing about the February temperatures in the two places. The February days in Ontario are cooler than those in British Columbia.

If you will find Victoria, British Columbia, and Windsor, Ontario, on a map, perhaps you will be able to discover why this is so.

Victoria is near the Pacific Ocean. Winds blowing over the city from the ocean are warm winds. They are warmed by the water in the Pacific Ocean.

Windsor is an inland city. The winds that blow over Windsor are not warmed by warm ocean water. February days are cooler here. You will notice on the record that Victoria had no snow in February.

The May weather records also show changes in the weather. Every day the observations were different.

If you keep weather records, you will find changes in the weather. Weather changes from day to day everywhere.

Cumulus clouds

## Clouds and More Clouds

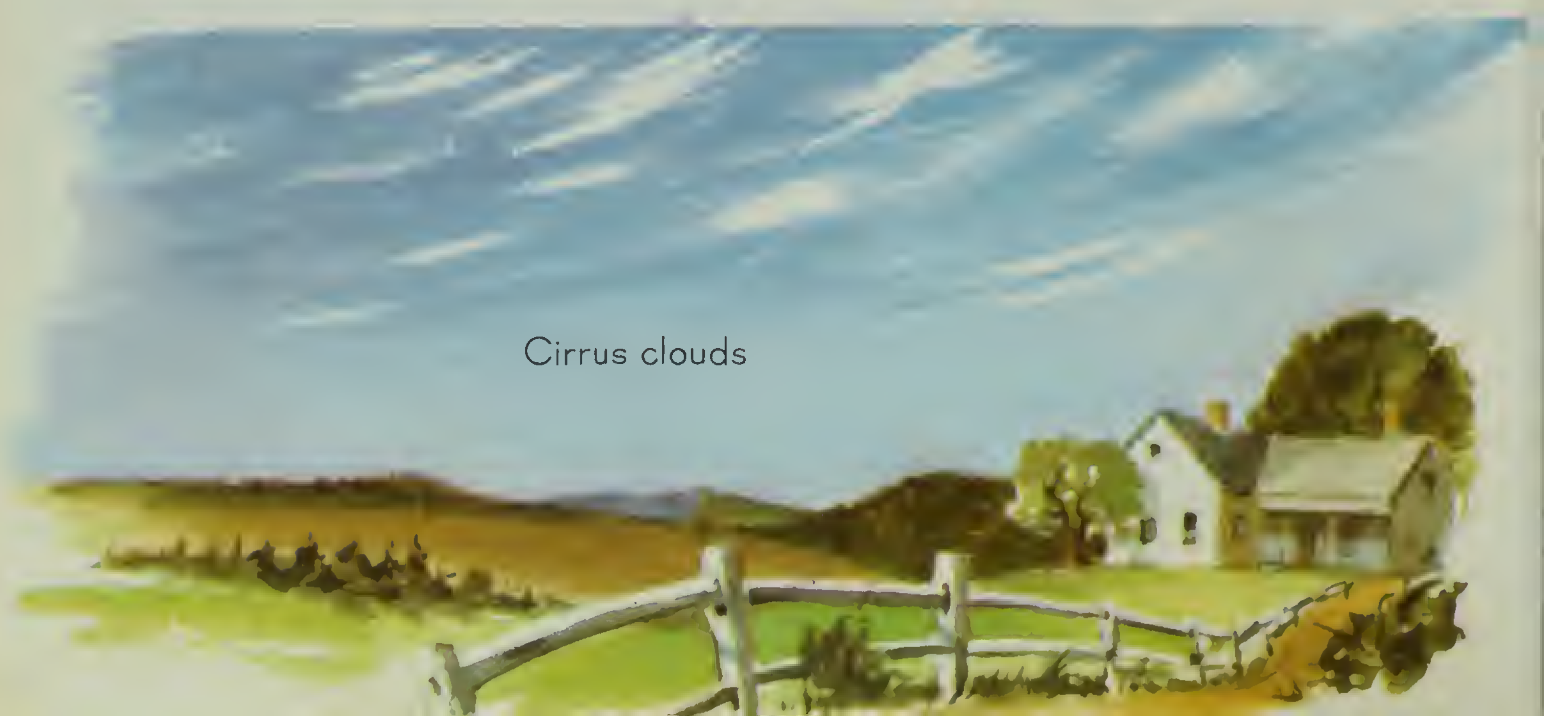
Did you ever lie on the grass and watch the clouds pass by overhead? Did some of the clouds remind you of fluffy, white sheep? Perhaps others reminded you of great castles. Still others may have reminded you of ships with tall, white sails.

It is fun to watch the clouds form pictures in the sky.

Usually the kinds of clouds that take such interesting shapes are like the ones you see above.

They are called cumulus clouds. They are the fluffy, fat, white clouds which are often seen in the sky on a fine, sunny day. Cumulus clouds may be seen at any time of the year.

At the bottom of this page are cirrus clouds. These thin, white, wispy clouds may also be seen at any time of the year. Sometimes they remind you of plumes made of feathers. Bright, blue sky can be seen between these clouds.



Cirrus clouds

Cirro-cumulus clouds

The clouds at the top of this page may be thought of as a combination of cirrus and cumulus clouds. These clouds are called cirro-cumulus clouds.

Sometimes, when the cirro-cumulus clouds are in lines, we say there is a mackerel sky. This is because the small, white clouds look something like the scales on a mackerel. The cirro-cumulus clouds in the picture above look something like fish scales. We could call this a mackerel sky.

At the bottom of the page is still another kind of cloud. This is called a stratus cloud. It is a low, thin, grayish-white cloud which covers the whole sky. A fine rain or drizzle might fall from a stratus cloud.

Sometimes the sky is covered by a layer of thick, dark-gray cloud. This is the kind of cloud you might call a rainy-day cloud or a snowy-day cloud.

This dark-gray rain cloud also has a scientific name. It is called a nimbo-stratus cloud.



Stratus clouds

If you turn back to page 44, you will see a picture of still another kind of cloud. This cloud is often called a thunderhead. Scientists call it a cumulo-nimbus cloud.

Many of us have learned to know thunderheads, or cumulo-nimbus clouds, because of their shape. They are tall, towering clouds.

Cumulo-nimbus clouds are usually flat at the bottom. Then they tower up and up. Sometimes the tops of these clouds spread far out.

At first these clouds may look white. Later on they look light gray, and then darker gray as they are blown nearer to you.

In the picture above is still another kind of cloud. You have probably never seen this kind of cloud in the sky. But you may have seen it in pictures. This is a tornado cloud.

A tornado is a very strong, twisting, and whirling wind. It is caused by colder air moving warmer air very, very rapidly over a small area.

Much damage has been done by tornadoes. But there is hope of being able to predict tornadoes so that people may be prepared for them. We are also learning to build houses that cannot be easily damaged by tornadoes.

Now you have seen pictures of six different kinds of clouds. They are cumulus, cirrus, cirro-cumulus, stratus, cumulo-nimbus, and tornado clouds.

Men and women who study the weather have named about five other kinds of clouds. We have named only one of the others. It is the nimbo-stratus, or rain cloud. Perhaps you will now begin to recognize some of these clouds.

# Clouds Help Us to Predict the Weather

It is fun to learn to recognize clouds. But there is another reason for learning about clouds. Watching the clouds can sometimes help you to predict the weather.

Many farmers have learned to recognize clouds. They have discovered that some clouds usually mean fair weather. Other clouds often mean rainy weather.

Farmers find that observation of clouds is very helpful. They are better able to know when to plant or to plow or to harvest if they know what the weather might be during the next day or two.

Of course farmers also make use of the daily weather reports that come over the radio. Your family probably listens to these, too.

The chart below shows what kinds of clouds were in the sky during certain weather. Notice the kind of cloud on a certain day and the kind of weather on the next day.

Cirrus clouds often mean that there will be rain or snow in about twenty-four hours. A mackerel sky, with its cirro-cumulus clouds, may mean the same thing.

Cumulus clouds are fair-weather clouds. This means that the weather is usually fine and sunny for from one to three days after we see them.

You probably know that stratus and nimbo-stratus clouds mean that rainy weather or even snow is ahead. When the sky is covered with these clouds, we prepare for wet or snowy weather.

Clouds and Weather, June 6-12

| | June 6 | June 7 | June 8 | June 9 | June 10 | June 11 | June 12 |
|---|---|---|---|---|---|---|---|
| Kind of cloud | Cirro-cumulus | Stratus | Nimbo-stratus | Cumulus | Cirrus | Stratus | Nimbo-stratus |
| Weather | Clear | Cloudy, then rain | Rain | Clear | Clear | Cloudy, then showers | Rain |

Of course thunderheads, or cumulo-nimbus clouds, mean thunderstorms. Usually these clouds appear in the afternoon or evening of a very hot day.

The thunderstorm usually passes quickly. Afterward the air is fresh and cool.

You may want to keep a record of the kinds of clouds that you see. First, you will need to learn to recognize the different forms of clouds. Record the forms in the morning and in the afternoon.

Be sure to record the kind of weather also. After you have kept your record for two weeks, study it carefully. Perhaps you too can learn something about predicting the weather from cloud forms.

## Weather Sayings

Rainbow in the morning,
Sailor take warning.
Rainbow at night,
Sailor's delight.

How many times people have said this old, old rhyme! It is one of the weather sayings that have much truth in them. Let's see why.

First, we need to think about the cause of a rainbow. For a rainbow to appear in the sky, there must be water in the air in the form of rain. Also, the sun must be shining.

Sunlight falls on the rain. The water droplets in the rain break sunlight into its different colors. Then we see a rainbow if we are between the rain and the sun.

In the morning the sun is in the east. Where would the rainbow be?

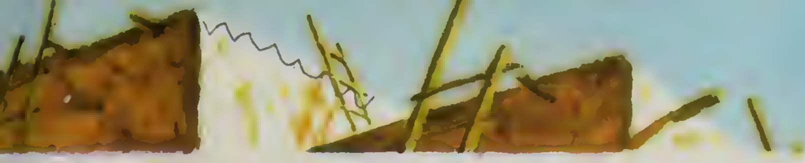
Yes, it would be in the west. Sunlight shines across the sky on rain in the west. Since storms often move from west to east, this may mean that clouds are on the way to us.

A rainbow in the evening would mean the rain is in the east. So the storm has probably gone past us.

There is another old weather saying that has much truth in it:

When the morn is dry,
The rain is nigh.
When the morn is wet,
No rain you get.

"The morn is wet" means that there is dew on the grass. Dew is formed at night when the air is clear, calm, and cool. After such a night the next day is often fair.



But if there has been no dew, it is usually because the air has been too warm for dew to form. Often warm air is also moist. Warm, moist air in the evening may mean that the next day will be cloudy.

Can you see, too, that this saying may also be true?

When spider webs in the air do fly,
The weather will soon be very dry.

Yes, spider webs are blown apart and fly about in dry air. And dry air usually means fair weather.

Certainly the next weather saying is often true:

When mountains and cliffs in the sky appear,
It means sudden and violent storms are near.

Clouds that look like mountains and cliffs are thunderheads. And we all know that a storm is near when such clouds appear. Of course the thunderstorm may be some distance from where you are. But often it is near enough for you to see lightning and hear thunder.

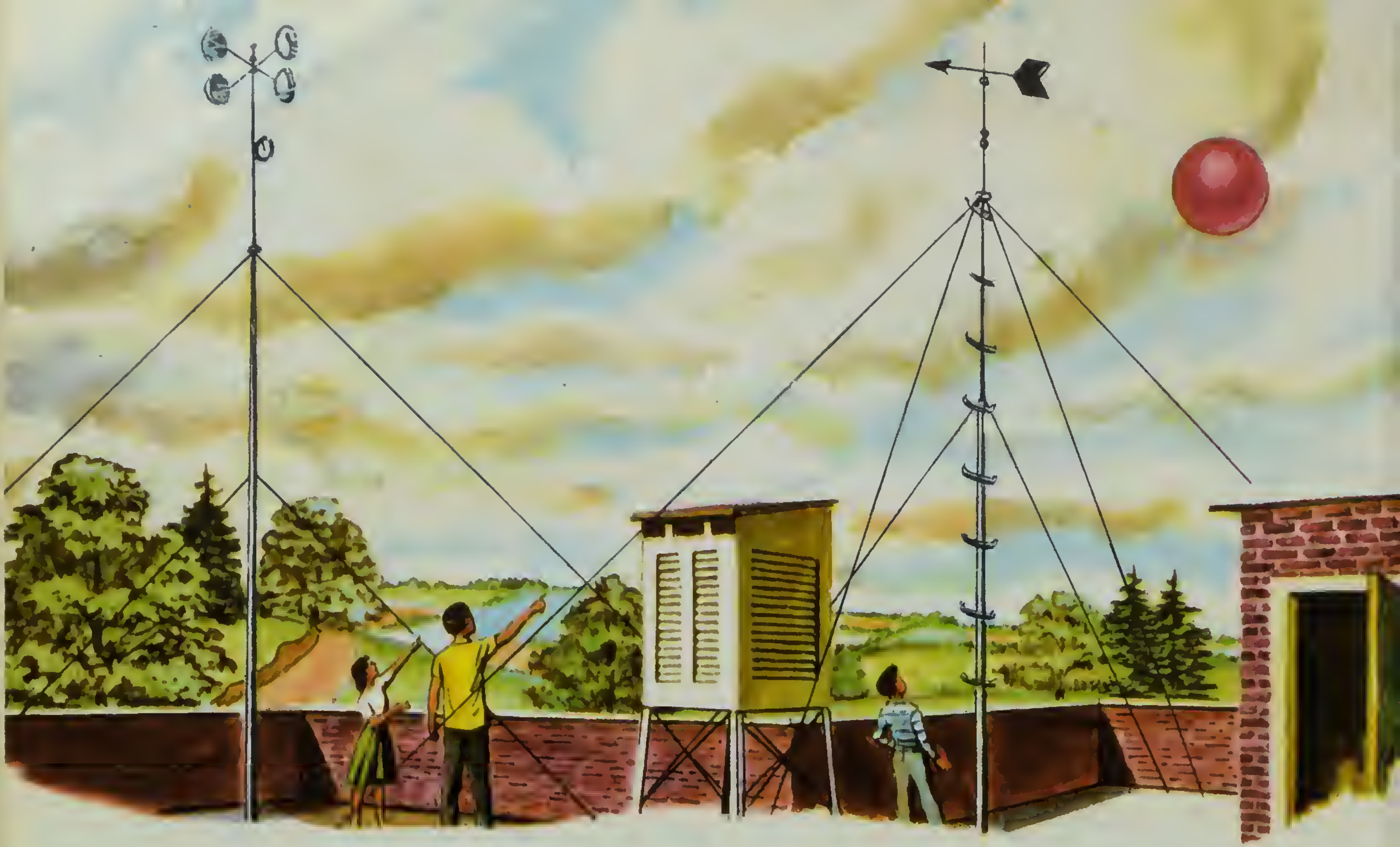
The Zuñi Indians of New Mexico give us this saying: "When the sun is in his house, it will rain soon."

By this saying the Zuñis mean that there is a ring around the sun. We know that the ring around the sun is formed by light striking very high cirrus clouds. High cirrus clouds often foretell rainy weather.

By checking weather sayings with the weather for many years, we have found that some weather sayings may be depended upon. In the same way we have discovered that others are untrue. This is one of the untrue sayings:

When the ground hog his shadow sees,
Six more weeks of winter there'll be.

We have discovered that even though it may have been fair on ground-hog day, February 2, we have had both fair and rainy weather during the next six weeks.



## Using Weather Reports

People listen to the weather reports that are given over the radio during the day. They read the weather reports in their newspapers. Each day the telephone rings often at the weather station.

Why do so many people want and need accurate information about the weather? The family is planning a picnic. Will this be a good day to go? They say, "Let's listen to the radio report to see what the weather will be."

It is Friday morning in the summer. The bakers need to know what the weather will be over Saturday and Sunday. If it is to be warm and sunny, many people will go into the country or parks on picnics. This means that they will need sandwiches.

The bakers need to know if the week end will be fair. If so, they will need to bake an extra supply of bread for sandwiches. They will bake more cakes and cookies.

Weather stations give out storm warnings. This is useful to automobile travelers, to farmers, and to sailors. Fishermen will not go out to sea in their small boats when they hear the storm warnings.

On the opposite page is a picture of a weather station.

As the balloon floats freely in the air, it tells about wind currents. Up on one of the tall poles is a wind vane. This instrument gives the direction of the wind. On the other pole is an anemometer. An anemometer tells the wind speed.

Inside the little house are the thermometers. Air can get to the thermometers through the small openings in the house. Weather stations have a barometer too. The barometer is kept inside the building because air pressure changes inside as much as it does outside.

All these and other instruments are used by the men and women who predict our weather. Their predictions are often right. Because weather reports are made carefully, many people can depend on them.

## THIS IS FOR YOU

1. Do weather changes make you feel different? Do you feel full of pep on a cool day? Do you suppose dogs, cats, and other animals feel weather changes, too?

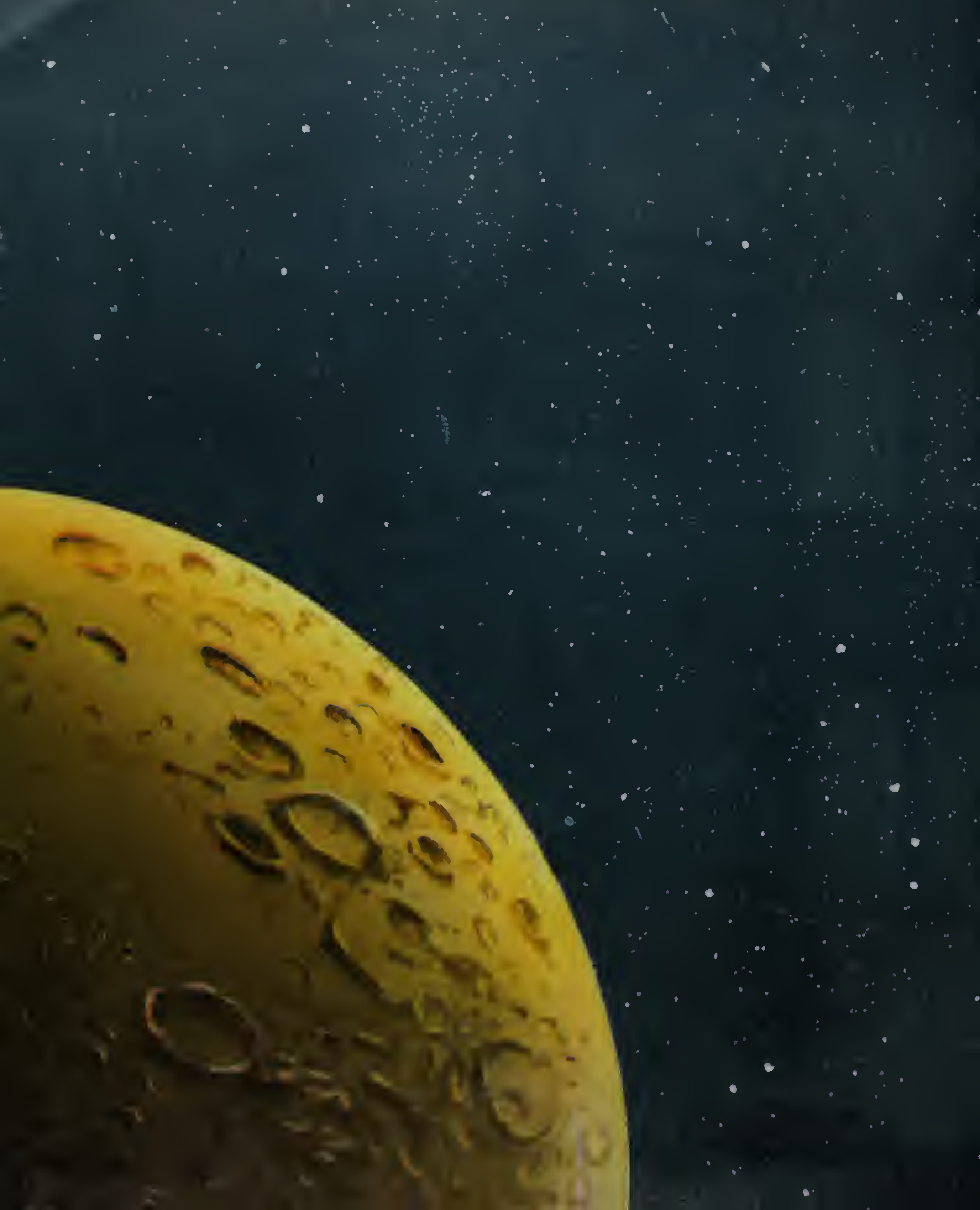
2. Find the weather report in your daily newspaper. Follow these reports for two weeks. See how often the reports are correct.

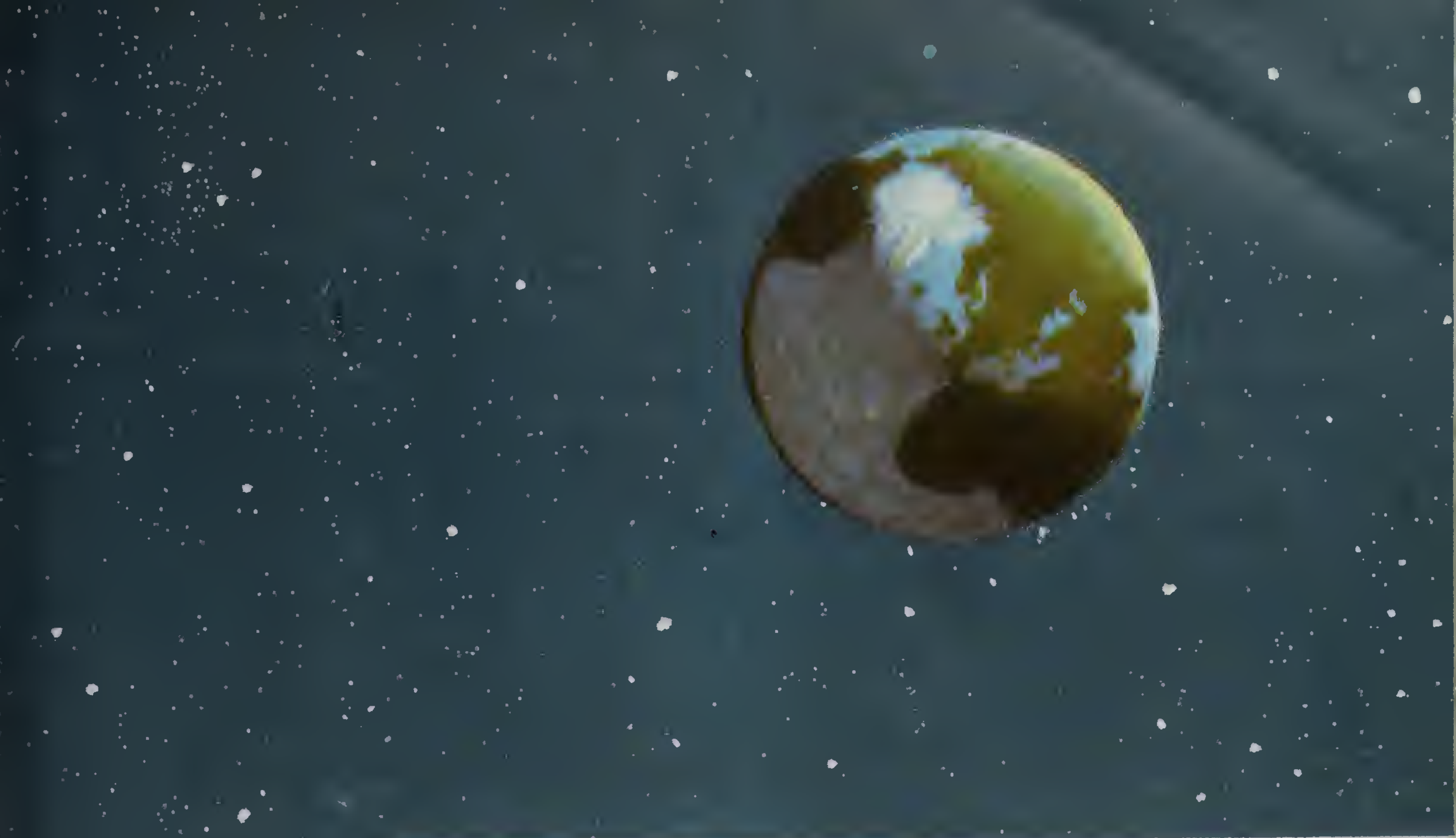
3. Write to the Meteorological Division, 315 Bloor Street West, Toronto, Ont., for a copy of "What You Can Do About the Weather." Mention your teacher's name.

4. Is there a weather station near you? If so, perhaps your group might plan a trip to the weather station. Telephone to see when it will be convenient for you to visit. You may want to jot down some questions to ask the workers at the weather station.

5. Do you know anyone in your neighborhood who has watched cloud forms often enough to predict the weather? Perhaps that person would be willing to help you to understand cloud forms better.

# Changes in the Sky



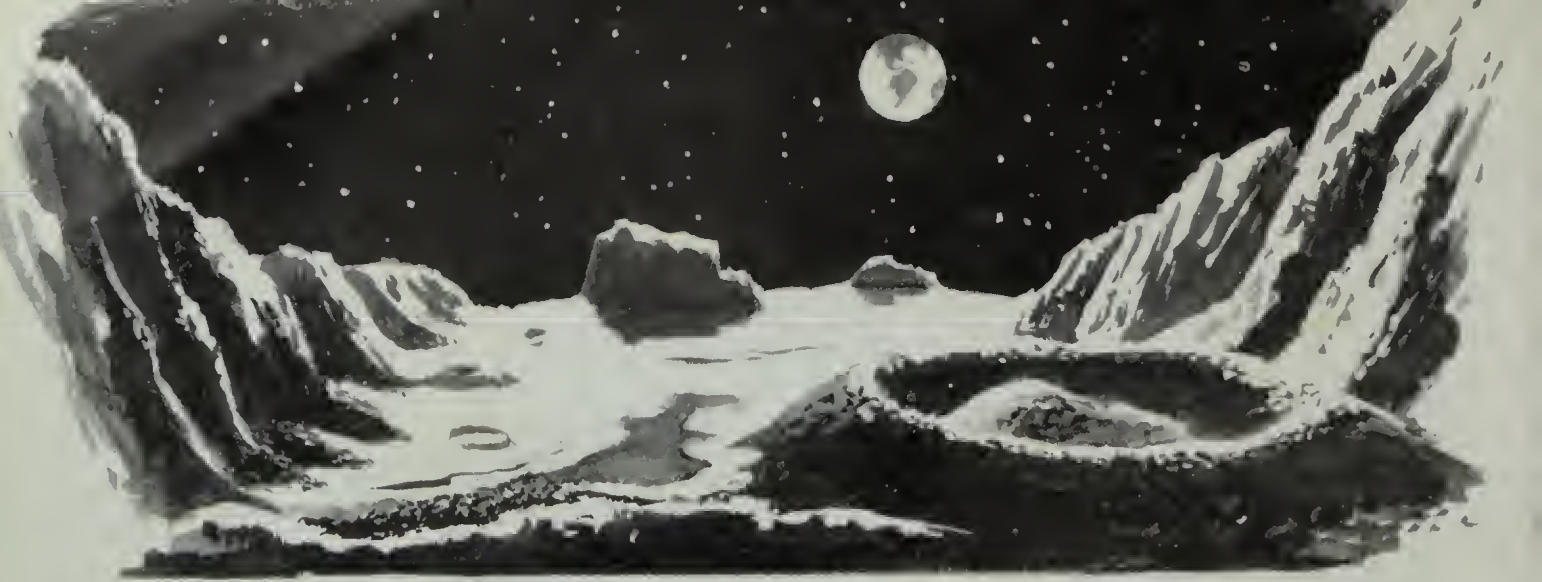


## The Nearest Sky Neighbor

If you lived on the moon, perhaps you would think the earth moves around the moon. For the earth would only look like a large, beautiful globe in the sky.

The earth would be large enough for the green-and-brown continents to be easily seen with a telescope. You would be able to see the blue-green oceans. You would be able to see the snow-capped north and south poles. Once in a while clouds would pass over parts of the continents and oceans. These clouds would be very white.

If you lived on the moon, you would see many stars all about you. They would be shining in a black, black sky. You would see the sun too. But in spite of all the beautiful things that you would see, it would not be pleasant to live on the moon.



The moon is our nearest regular sky neighbor. Sometimes other sky bodies come nearer to the earth than the moon does, but not for very long.

The sun is much farther away from us than the moon. It is about 385 times as far away from the earth as the moon is.

To get a better idea of these distances, think of any place about a mile from your school. Think of the moon as being at that place. Now find a city in your province, or in another province, which is about 385 miles away from your school. Think of the sun as being there. Does this help you to see how near the moon is to the earth?

But even though the moon is nearer than the sun, it would take quite a while to reach the moon.

Suppose you could fly to the moon in an airplane traveling 400 miles an hour. It would take you about 25 days, traveling day and night, to reach the moon.

The moon is shaped like a ball. It is certainly a large ball, though. If you could travel straight through the middle of the moon, you would make a trip of about 2000 miles.

Find Vancouver on a map. Now find a city which is about 2000 miles away. This is how far you would travel if you could travel straight through the moon.

Our earth is larger than the moon. If you could travel straight through the middle of the earth, you would make a trip of about 7900 miles. It is almost four times as far through the earth as it is through the moon.

When you reached the moon on your imaginary airplane trip, it would probably look somewhat like the picture on the opposite page. There would be no trees, no grass, no flowers. There would be no birds, or cows, or ants, or horses. There would be no human being besides yourself.

There would be no wind, no rain, no snow, no clouds. The moon is a rather dreary place.

There is a reason why it would be hard for things to live on the moon. For this same reason there is no weather on the moon. The reason is that there seems to be no air or water.

It certainly would not be very easy or pleasant for us to try to live on the moon.

There are high places and low places on the moon. Some moon mountains are higher than others. The highest are about as high as the earth's highest mountains.

The lower places on the moon are probably covered with small stones very much like gravel. If so, these small stones may have broken off from larger rocks and tumbled down the mountainsides.

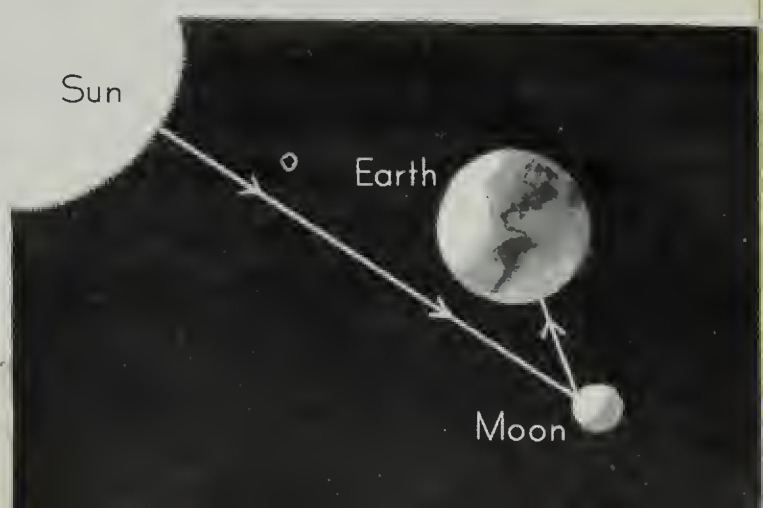
Small stones would break off from the larger rocks because the rocks of the moon become very hot and then very cold. The moon becomes very hot during its day, since there is no thick atmosphere to protect it from the sun's great heat.

The side of the moon turned away from the sun becomes very cold. There is no thick atmosphere to hold heat close to the moon.

Moonlight seems softer than sunlight. Yet moonlight is really sunlight.

Have you ever caused light to be reflected? A mirror reflects light very well. Hold a mirror so that sunlight falls on it. Can you make light dance about the room? The sunlight strikes the mirror and is turned, or reflected.

The moon acts something like a giant mirror. The sun shines on the moon, and the sun's light is reflected. This reflected light of the sun is our moonlight.



The moon seems much larger at some times than it does at other times. Just as it is rising, the moon often looks larger than it does when it is high in the sky.

The picture at the top of this page shows the moon just as it is rising. The picture on the next page shows the moon high in the sky. In each picture the moon is exactly the same size. But it looks larger in the picture at the top of this page.

When the moon, trees, and houses are all seen at the same time, we can compare their sizes. It is easy to see that the moon is much larger than trees or houses.

But when the moon is high in the sky, it looks smaller. The reason is that there are no trees or houses nearby to compare it with.

Even on the same night the moon seems to change in color. Often when the moon first rises, it looks quite red. Later on, when it is high in the sky, it looks silvery white.

This is not because the moon reflects less light to us when it is high in the sky. About the same amount of light reaches the earth from the moon from hour to hour during any one night.

Because of the dust in the atmosphere, the moon often looks red or red-gold when it begins to rise. There is more dust between our eyes and the moon at that time. Dust scatters the moon's light. But the red and yellow parts of its light are not scattered as much as the other parts. This is why the moon may look red when it rises.

Dust in the atmosphere affects the sun in this way, too. You probably remember that the sun looks much redder when it rises or sets.

But you may be thinking, "There is dust in the air when the moon and sun are high in the sky, too! Why doesn't the moon look red when it is high? Why doesn't the sun look red then, too?"

Yes, there is dust in the atmosphere all the time. But we do not look through as much of the dusty atmosphere when we look straight up as we do when we look out toward the distant horizon. We are looking through more of the dusty atmosphere when the moon is rising than when it is high in the sky.

## The Moon's Shapes

Every month the shape of the moon seems to change several times. For a while the moon is just a thin, silver crescent. Then this crescent, which we call the new moon, seems to grow larger each night.

Finally, we see a round, bright moon for a few nights. When the moon is most round, we say, "Tonight the moon is full."

Then the moon seems to shrink. Each night it seems to be smaller than it was the night before. Finally, no moon can be seen.

Early people, watching the moon every night, thought the moon's shape really did change from night to night. We know now that the moon's shape does not really change. It only seems to do so.

New crescent moon

First-quarter moon

Full moon

Last-quarter moon

Old crescent moon

The moon goes through these different changes from new moon to no moon at all in about 29 days. Or we could say the same thing this way: "Once every 29 days there is a new moon." Or we could say, "Once every 29 days the moon is full. All these are ways of saying that the moon seems to change in shape. This has been happening month after month, year after year, for as long as man can remember.

Sometimes you see the moon in the daytime. Whenever you do see the moon during the middle of the day, it is never a full moon. A full moon can be seen only in the early morning before sunrise, in the early evening after sunset, or during the night.

A crescent moon can never be seen late at night. It can be seen in the early morning before sunrise. Or it can be seen during the day, or in the early evening just after sunset.

A full moon seems very bright during the night. But it is not nearly so bright just before sunrise or just after sunset. A crescent moon seems much brighter in the very early morning or in the evening. It is very pale during the daylight hours. Sometimes you have to look very hard to see the crescent moon during the day.

Here is an experiment that may help you to understand why the moon looks pale during daylight hours: For this experiment you will need a darkened room and a flashlight.

After your room is darkened, turn on the flashlight. While the flashlight is still on, turn on the overhead lights. You will notice that the ray of light from the flashlight now seems to be much less bright than it did when the room was dark.

The flashlight seems to be less bright because the overhead lights are so much brighter than the ray from the flashlight.

The next experiment may help you to see why the moon's shape seems to change from night to night. First, we need to know that the moon travels around the earth. It takes about 29 days for the moon to go around the earth one time.

For this experiment you will need an old tennis or ping-pong ball. Or an orange will do. You will also need a steel knitting needle and a bright light. A bridge lamp will do very well.

Look at the picture below. Notice that the shade of the lamp is tilted so that the light shines across the room. Put the knitting needle through the tennis ball just as the boy in the picture has done. Now you can hold the ball easily.

Hold the needle so that the ball is a little above your head. Be sure that the light shines on the ball.

Now, with your arm straight out before you, turn around slowly. As you turn around, watch the ball. The light is falling on the ball all the time. You will see that the part of the ball which is lighted seems to change its shape.

As you face the lamp, with the ball held out in front of you, you cannot see the lighted part of the ball. As you slowly turn around, first you see a crescent. Then you see half the ball fully lighted.

As you turn more, there is another crescent. Then, finally, no lighted part can be seen.

Let us say that the lamp represents the sun. The ball represents the moon, and you represent the earth. The moon-ball is moving around the earth.

At first you see no lighted moon-ball. Then you see a crescent moon-ball. Then you see a full moon-ball. Then you see another crescent moon-ball. Finally, you see no lighted moon-ball at all.

As we have said, it takes the moon 29 days to go through these changes, or phases. Each change is called a phase of the moon.

At times only a small part of the moon-ball seems to be lighted. But this is not true. At least half of the moon-ball is lighted at all times.

To see this yourself, ask a friend to stand in your place and move the moon-ball.

As you stand near the lamp, watch the moon-ball. As it is moved around, you can see that half of it is always lighted. You can see the different phases only when the moon-ball moves around *you*.

If you could float about in the sky out near the sun, you would not be able to see the phases of the moon. In order to see the phases of the moon, one must be on the earth.

There are two reasons, then, for the phases of the moon. One reason is that the sun lights the moon. The other reason is that the moon moves, or revolves, about the earth.

An eclipse of the sun

## Eclipses of the Sun and Moon

As the moon revolves about the earth, it sometimes comes between the earth and the sun. This does not happen very often.

When it does happen, the sun is blotted out for the people who are in the moon's shadow. This blotting out is called an eclipse of the sun.


Men and women who study the sun, earth, and moon know when an eclipse of the sun will happen. They are able to predict an eclipse of the sun because the sun, earth, and moon move so regularly year after year.

These people who study the sky and the bodies in the sky know exactly when the moon will come between the earth and the sun. They know exactly how large the moon's shadow on the earth will be. They know exactly how long the shadow will last.

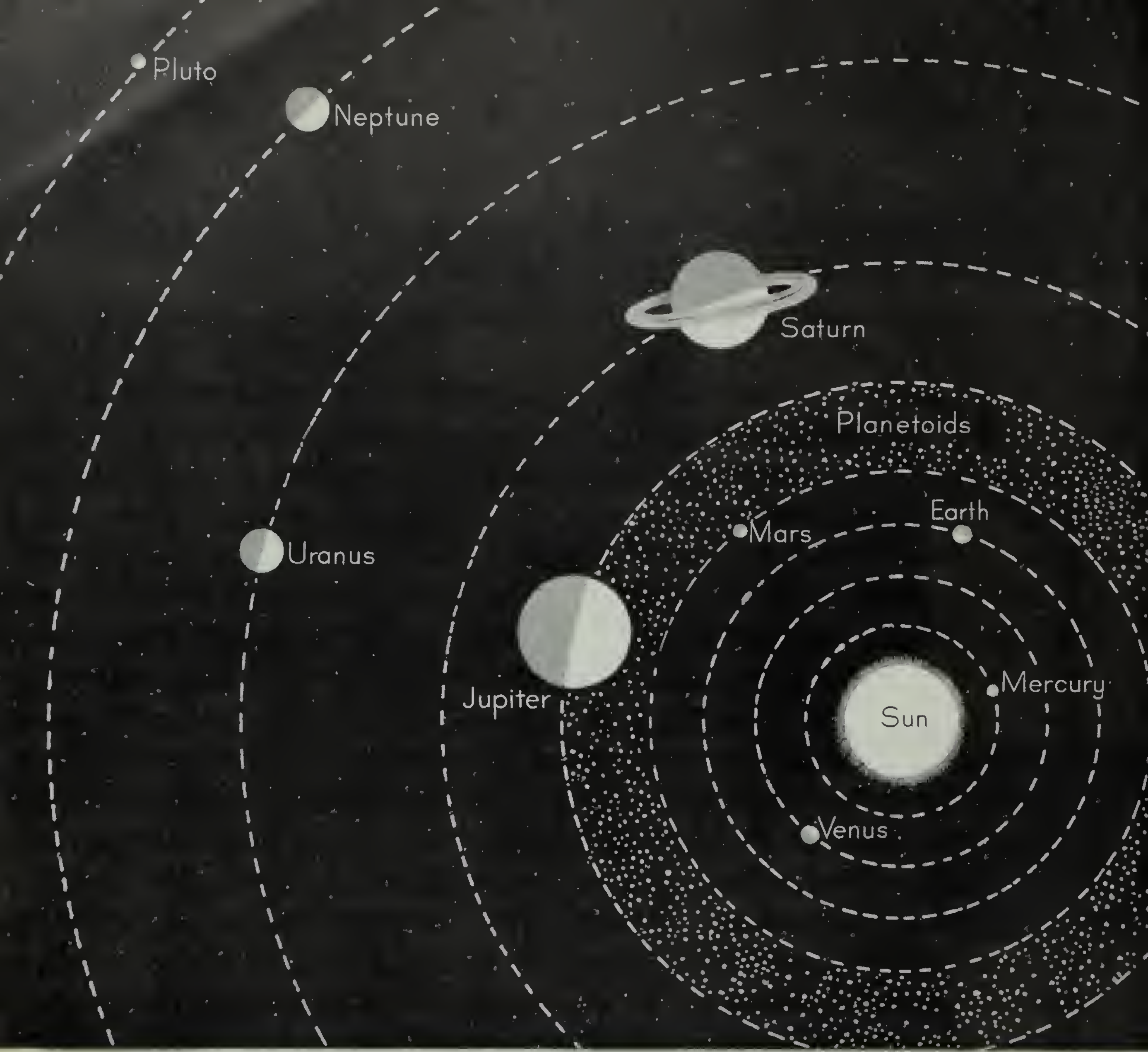
At one time people did not know when eclipses would happen. They did not know what caused eclipses. For this reason an eclipse of the sun was a very frightening thing to most people.

Sometimes we have an eclipse of the moon. Whenever the earth is directly between the moon and the sun, we cannot see the moon.

The reason we cannot see the moon is that the sun's light is cut off from the moon by the earth. So the moon is not easy to see.

An eclipse of the moon can happen only when there is a full or nearly full moon. This is the only time the earth can be directly between the sun and the moon.

People who study the sky can predict eclipses of the moon also. They predict eclipses so accurately that they know exactly how long the moon will be in the earth's shadow. Our radios and newspapers bring the news of eclipses to us, so that we are not frightened.




## The Sun's Family

The earth has only one sky body that revolves about it. This sky body is the moon. The earth revolves about the sun.

Other sky bodies revolve about the sun also. Among these are the planets, the planetoids, the comets, and the meteors.

The most familiar planet to us is the earth because we live on it. It seems very large to us, but really it is one of the smaller planets in the sun's family.

Our planet, the earth, has a diameter of about 7900 miles. Suppose we could travel straight through the earth in an airplane going 400 miles an hour. It would take us a little less than 20 hours to make the trip.

Some of the planets are smaller than the earth. These planets are Mercury, Venus, Mars, and Pluto.

The smallest planet, Mercury, is also the one which is nearest the sun. It has a diameter of only about 3000 miles. A trip straight through Mercury in our 400-mile-an-hour airplane would take us only about $7\frac{1}{2}$ hours.

Mercury is hard to see because it is so near the sun. The sun's light is so bright that the best time to see Mercury is when the planet comes between the earth and the sun. When this happens, Mercury looks like a black dot against the sun. The picture on this page shows how Mercury looks when it comes between us and the sun.

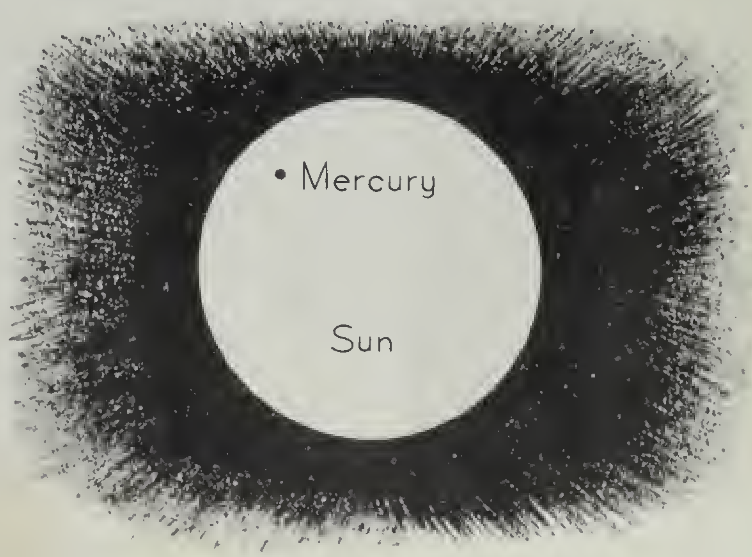
Notice how much smaller Mercury is than the sun. The sun's diameter is about 288 times that of Mercury.

There is no moon revolving about Mercury. This small planet travels about without any near neighbor.

Mercury is nearer the sun than the earth is. It does not have to travel as far as the earth does to make one complete trip around the sun. Also, Mercury travels faster than any other planet.

It takes only about 88 days for Mercury to revolve about the sun. As you probably know, it takes the earth about 365 days to make one trip around the sun.

Another interesting thing about Mercury is that one side has day all the time. The other side of Mercury is always in darkness. It would not be possible to live on Mercury. If you tried to live on the dark side, you would freeze. On the bright side you would be far too hot.



The pictures on this page do not show phases of the moon. They are pictures of the phases of Venus. There are two planets nearer the sun than we are. We have seen that one of these planets is Mercury. The other one is Venus. Like Mercury, Venus goes through phases for us here on the earth. When Venus is full, this planet is at its greatest distance from the earth. A full Venus looks smaller than Venus at any other phase.

The sun is so hot that it gives off light and heat in all directions. But this is not true of any of the nine planets. All planets are seen because they reflect light. We see the planets only because they reflect the sun's light to our eyes. We can see only the lighted part of a planet.

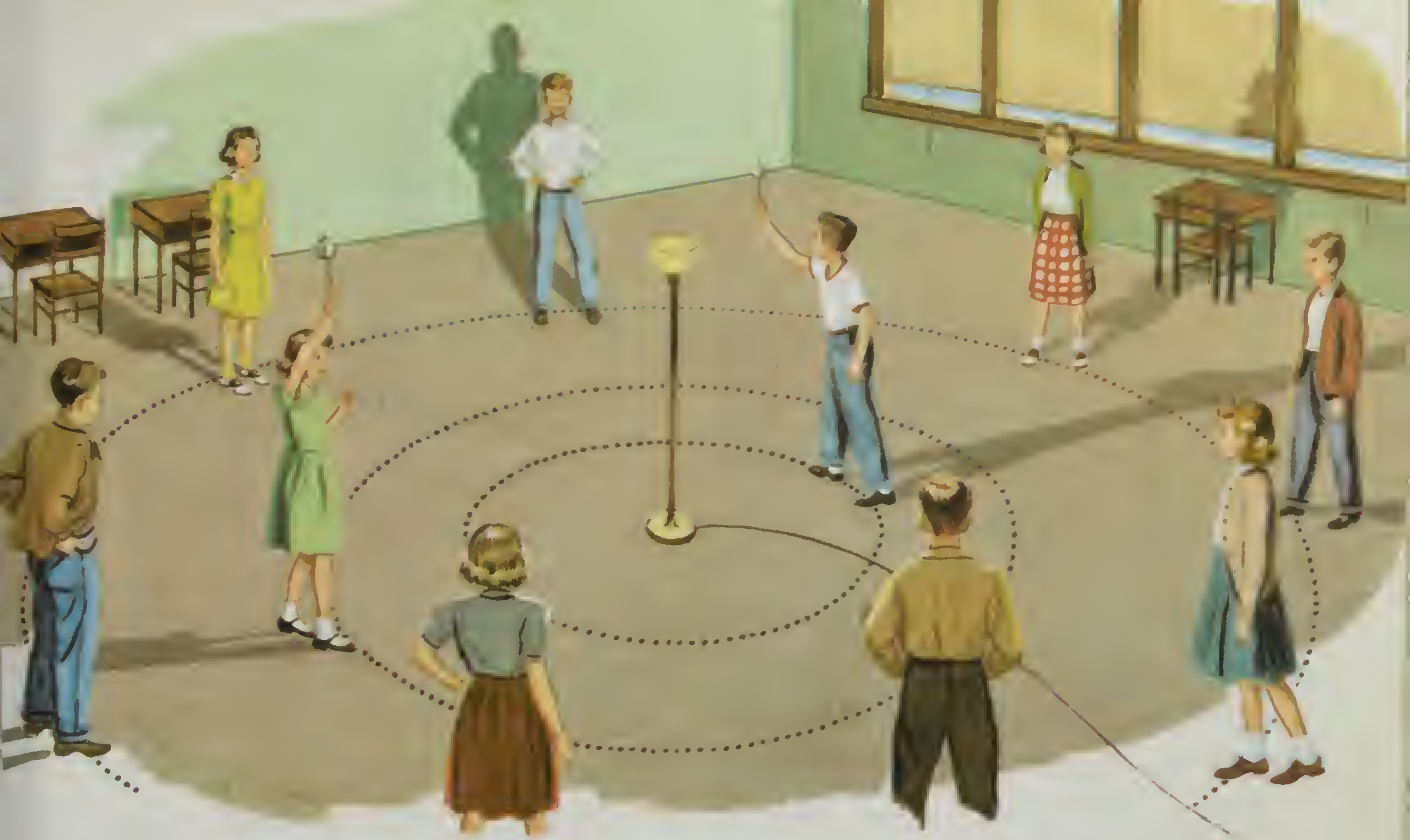
Here is an experiment that may help you to understand why only the planets Mercury and Venus go through phases for us here on the earth: Use a ping-pong ball for Mercury and an old tennis ball for Venus. You can hold the balls more easily if you put a steel knitting needle through each of them.

A bright light, such as that from a bridge lamp, could be used to represent the sun. The shade should be removed from the lamp, and the lamp should be placed in the center of the room.

In the picture on the opposite page the ping-pong ball, held by the boy, represents Mercury. This boy moves in a circle around the bridge lamp. He will be nearer the lamp than anyone else in the room.

The girl's tennis ball represents Venus. The girl will also move in a circle around the bridge lamp. But this will be a larger circle.

Each of the other children represents the earth in a different position as it moves around the sun.



As the girl and the boy move around the sun, one side of each ball is always lighted. However, the children representing the earth at different places in its travels do not always see all the lighted part of the balls.

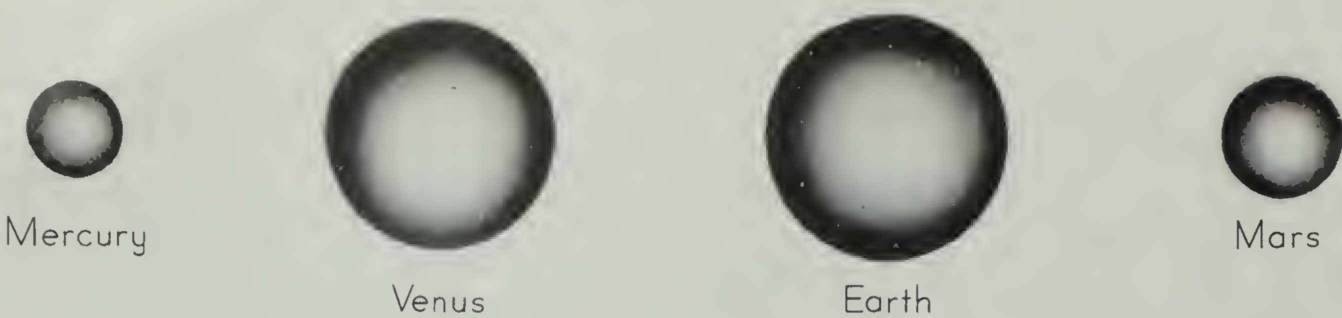
Sometimes they see only a tiny part of the lighted side of a ball. Then they would see a crescent. At other times they see a larger part of the lighted side. Then they may see a quarter of the ball.

At still other times they see all the lighted side. This is when they see a full Venus or a full Mercury.

These two planets go through phases for us here on the earth because they are between the earth and the sun.

Use another ping-pong ball to represent Mars. The child who holds this ball must travel in a circle larger than the earth's circle. This child will travel around all the other children in the room.

Everyone always can see all the lighted part of Mars. Neither Mars nor any of the planets beyond Mars go through phases for us here on the earth. This is because they are farther away from the sun than we are.




The four balls above show Mercury, Venus, Earth, and Mars in correct proportion. Of course this does not mean these four planets are only this large. It does mean these planets are shown in the correct sizes in relation to each other.

Venus is almost the twin of the earth in size. This planet's diameter is only a little less than the earth's, being about 7700 miles.

You know that Venus is nearer the sun than the earth is. Venus travels faster in its path around the sun than we do. For these reasons it takes Venus only about 225 days to go around the sun.

If you lived on Venus, you would have birthdays more often than you do on the earth. If you are ten years old now on the earth, you would be sixteen and a fourth years old on Venus. Since it takes Venus less time to move around the sun than it takes the earth, a Venus year is shorter than ours.

No one knows how long a day is on Venus. It may be that there is always day on one side of Venus and always night on the other side.

Venus has a very thick atmosphere. No one can see through this atmosphere to the surface of Venus. So no one knows whether Venus turns on its axis or not.

Because of this thick atmosphere Venus is a very good reflector of light. This planet is very often the brightest body in the night sky except the moon.

No moons travel about Venus. Like Mercury, this planet has no near sky neighbor revolving about it.

So far as we know, no people could live on Venus. This planet does not seem to have the same kind of atmosphere as the earth; so people such as we could not breathe very well there. Also, if Venus does not turn on its axis, one side would be too hot and the other too cold.

# About Mars

Is Mars the planet which interests you most of all? The picture at the bottom of this page shows Mars with the two small moons which revolve about this planet.

Imagine having two moons! If you lived on Mars, there would always be moonlight. Most nights two moons would shine at one time.

There would be few clouds to hide the moons. This is because there is very little water on Mars. Very little water means that there are few clouds in the atmosphere.

The moons of Mars are much smaller than our moon. One of these moons has a diameter of only about 10 miles. The diameter of the other moon is only about 5 miles.

Such tiny moons do not reflect much light. So, even, with two moons, the nights on Mars would not be very bright.

If you lived on Mars and watched the moons, you would notice still another strange thing about them. One moon would go through all its phases in about $7\frac{1}{2}$ hours. Then the phases of this moon would begin all over again!

The second moon would go through all its phases in about 30 hours. Then this moon would go through all its phases all over again.

Even though the moons would be interesting to watch, it would not be much fun to try to live on Mars. As we have said, there is very little water on this planet.

During part of the year the water seems to be frozen at the poles. This water may be in the form of snow or, perhaps, frost.

You can see one of these white caps in the picture below. This cap is at one of the poles.

During half of the year on Mars the south pole is covered with a white cap. During the other half of the year the white cap of the south pole disappears. At this same time a white cap appears at the north pole.

This means that there must be seasons on Mars, just as there are on the earth. But each of the seasons would be about twice as long as each of our seasons. This is because a year on Mars is about twice one of our years. In other words, it takes Mars about 687 of our days to go around the sun.

Mars is farther away from the sun than the earth is. It also moves more slowly as it revolves about the sun. A day on Mars would be about the same length as an earth day.

Think of how many days you would wait for a birthday to come! How old would you be on Mars?

Let us pay an imaginary visit to Mars. Traveling in a spaceship going 1000 miles an hour, you would take almost 6 years to reach Mars. It would take you this long if you traveled day and night.

You would need an oxygen tank. This is because the atmosphere of Mars does not contain enough oxygen for people to breathe properly.

Warm clothes would be needed, too. The very warmest place on Mars on the very hottest day would be only about 86 degrees. It would be very cold at night.

There may be a few plants on Mars, but they are small plants such as moss. There would be no birds, no cows, no horses. There would be no animals of any kind, so far as we can tell.

If we should ever visit Mars, we probably would not stay long. Earth is a better planet for people.

# About the Distant Planets

Out beyond Mars are five more planets. These five planets are shown here in proportion to the earth.

All of these planets are very cold, even on their lighted side. The warmest one on the very hottest day of its year would be 216 degrees below zero. Would it be possible for plants and animals to live on these planets?

The reason for the great cold on these planets is that they are so far away from the sun. Jupiter, the closest one of the five, is more than five times as far away from the sun as the earth is.

There is another reason why it would be impossible for plants or animals to live on Jupiter, Saturn, Uranus, or Neptune. Each of these four planets has poisonous gases in its atmosphere. No one knows about the atmosphere of Pluto, since it is so far away.

Jupiter is a beautiful sight through a telescope. It looks like a great golden ball with light and dark bands around it. Jupiter is the largest planet in the sun's family. Its diameter is about 88,000 miles. It would take about 220 hours, or 9 days, for our 400-mile-an-hour airplane to fly straight through Jupiter.

Twelve moons revolve about Jupiter. Some nights on Jupiter several of these moons could be seen at one time. Sunrise would come much more quickly each day on Jupiter than it does here. A day and night would be only about 10 hours long. But birthdays would come only once about every 12 of our years!

On Saturn, birthdays would come only once in almost 30 of our years because Saturn is so far away. But sunrise would come about every 10 hours!

Saturn is a very beautiful planet when it is viewed through a telescope. Then the rings of Saturn may be seen. These rings are thought to be made of many, many moonlike bodies.

There are so many of these small "moons" and they move so rapidly that they seem to make solid rings around the planet. The rings are not really solid, though.

The rings of Saturn only look solid. When a bicycle wheel turns very fast, it looks solid. But you know that it is made of a number of spokes. The moonlike bodies travel around Saturn so rapidly they seem to form rings. Besides its rings Saturn also has nine moons.

Uranus and Neptune are about the same size, but Neptune is farther from the sun. It takes about 84 of our years for Uranus to revolve about the sun. It takes Neptune 165 of our years to revolve once. Just think how long it would take our birthdays to come around on Uranus and Neptune!

Sunrise comes on Uranus once about every 11 hours. On Neptune it is about 16 hours from sunrise to sunrise.

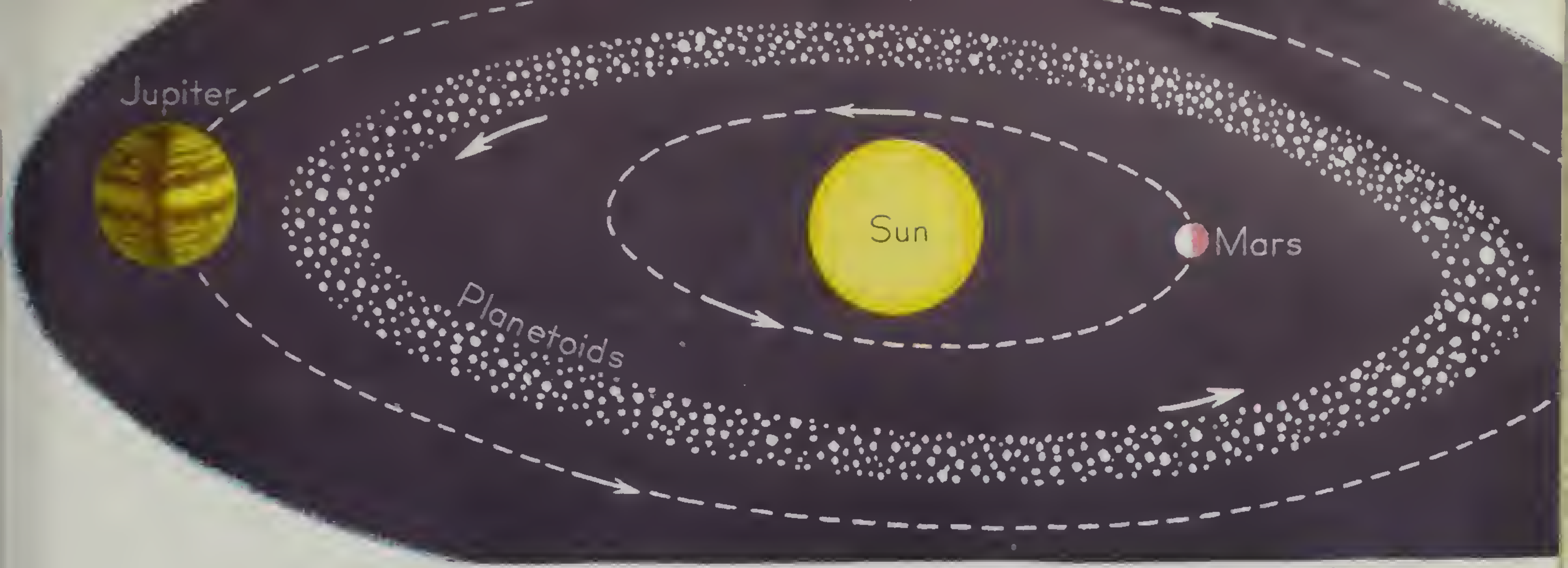
Uranus and Neptune also have moons. Uranus has five moons, and Neptune two.

Pluto is so very far away that we know little about it. We think that it is about the size of Mercury and that it probably has no moons. It takes about 248 years for this planet to revolve once about the sun!

To get a clearer idea of the sun's family, you might like to make a model out of doors, using the figures given below. These figures show the correct sizes of the planets in relation to each other. They also show distances in correct proportion to true distances.

The sun should be a ball with a diameter of about 1 foot. The size of each planet-ball and its distance from the sun are given.

| PLANET | SIZE OF BALL | DISTANCE FROM SUN |
|---|---|---|
| Mercury | $\frac{1}{23}$ inch | 39 feet |
| Venus | $\frac{1}{9}$ inch | 72 feet |
| Earth | $\frac{1}{9}$ inch | 100 feet |
| Mars | $\frac{1}{17}$ inch | 152 feet |
| Jupiter | $1\frac{1}{5}$ inch | 520 feet, or $\frac{1}{10}$ mile |
| Saturn | 1 inch | 954 feet, or $\frac{1}{6}$ mile |
| Uranus | $\frac{1}{2}$ inch | 1919 feet, or $\frac{1}{3}$ mile |
| Neptune | $\frac{1}{2}$ inch | 3007 feet, or $\frac{3}{5}$ mile |
| Pluto | $\frac{1}{26}$ inch | 3946 feet, or $\frac{7}{9}$ mile |




# The Little Planets

A great many very small planets also revolve about the sun. Most of these small planets, or planetoids, move around the sun in paths which lie between the paths of Mars and Jupiter. In the picture above only a few of these planetoids are shown.

About 1500 of these small planets have been counted so far. Some of the men and women who study the sun's family think that there might be as many as 40,000 planetoids!

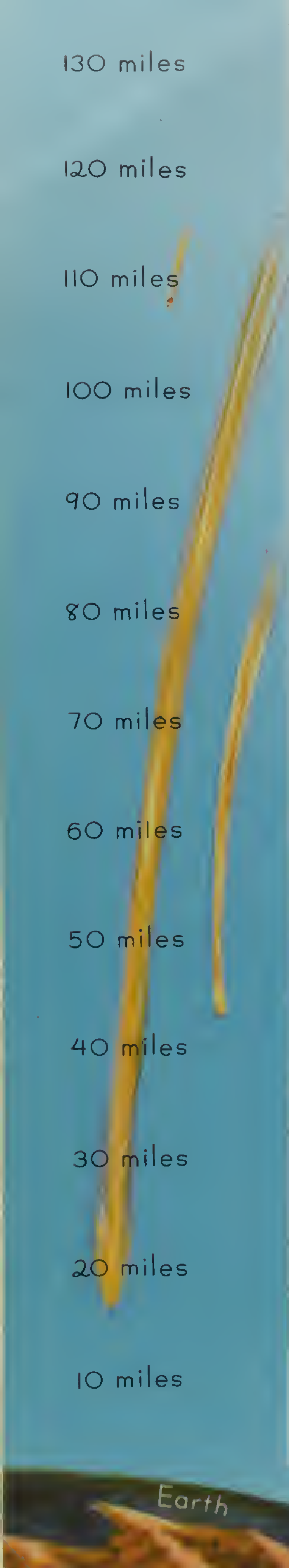
The largest planetoid is named Ceres. It has a diameter of about 480 miles. Traveling in a 400-mile-an-hour airplane, it would take about one hour to fly straight through the middle of Ceres. This is, indeed, a very small planet.

Some of the planetoids that have been seen with a telescope are no more than a mile in diameter. There are probably even smaller ones that have not yet been seen.

The planetoids do not have air or water. They are probably just large pieces of rock.

No moons revolve about the planetoids. The only light on their night sides would come from stars and from the planets out beyond them. There would be a day side on each planetoid, since the sun shines on the planetoids, just as it does on the larger planets.

So far as we know, there are no living things on a planetoid. This is because there is no air and no water on any of them.




# Meteors Visit the Earth

It is fun to watch the sky on a starry, moonless night, especially in summer. This is when we can see "shooting stars," or "falling stars," most easily.

*Shooting star* or *falling star* is not a very good name for these visitors to the earth. A better name for bodies of this kind is *meteor*. A meteor is a piece of dust or rock that has fallen into the atmosphere of the earth.

"But what makes the piece of dust or rock bright and shining?" you may be thinking. The reason for this is that the meteor is burning. When you polish furniture with a cloth, the furniture gets warm. When you sandpaper wood, the wood gets warm and so does the sandpaper. When things rub together, they become warm.

Now try this experiment: Rub your hands together very slowly ten times. Now rub your hands together as fast as you can ten times. Do you feel how much more heat there is when the rubbing is fast? You could try this same thing with two pieces of wood.

The air is a real thing. You know this because you have seen moving air, or wind, cause trees to move back and forth. Sometimes rapidly moving air, or a high wind, pushes against us so hard that it is not easy for us to walk.

Meteors are also real things. They are pieces of dust or rock. When these real things, air and dust or rock, rub against each other, the dust or rock is heated. Meteors do not move slowly. They move very, very fast. Some of them move at a speed of more than 100,000 miles an hour. It is easy to see why meteors get so hot that they burn.

Millions of meteors enter the earth's atmosphere each day. Most of them are so small that at night their light can be seen only with a telescope. It is also hard to see meteors in the day sky because of the sun's brightness.

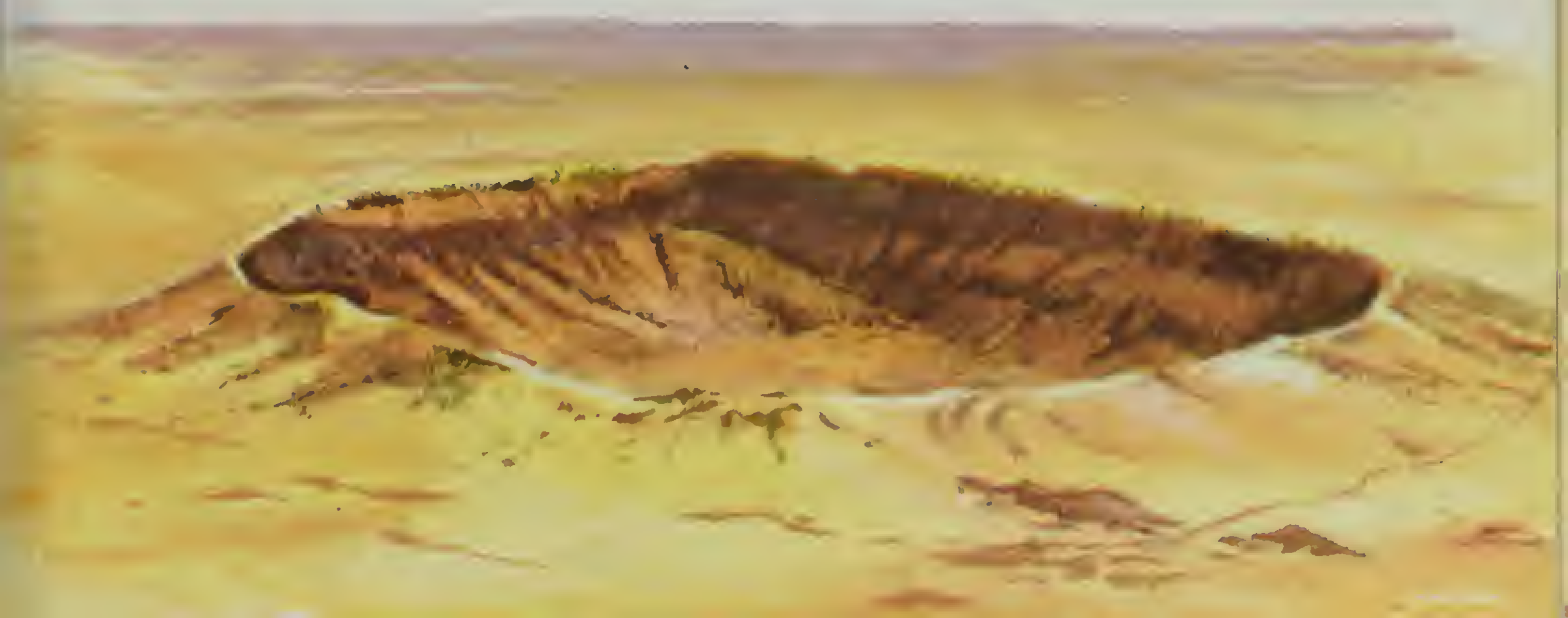
Most meteors that come to the earth are the size of a speck of dust. They are not even as large as a grain of sand. These meteors begin to burn when they are about 100 miles above our heads. They turn to gases before they ever reach the solid part of the earth.

Once in a great while a very large meteor comes within the earth's atmosphere. Sometimes it does not turn completely to gases before it reaches the solid part of the earth. At the top of this page is a picture of one of these meteors which reached the solid part of the earth before it was burned completely.

These remains of meteors are called meteorites. A meteorite looks somewhat like a clinker from a furnace, and most are about that same size. Meteorites are partly burned; so there are holes in them.

The great hole, or crater, shown in the picture below was probably made by a meteor. The largest yet found is the Labrador Crater, discovered in 1942. It is $2\frac{1}{2}$ miles across and several hundred feet deep.

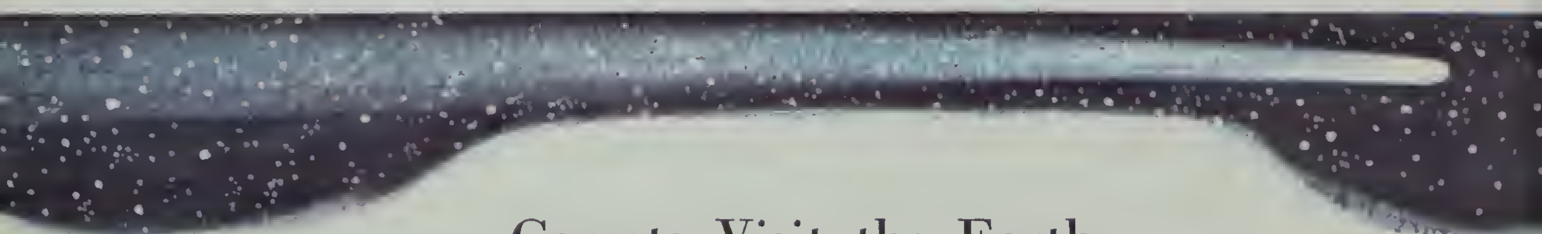
Probably this great meteor fell long before any people were living in North America. Not even the legends of the Indians tell of its fall.



In 1908 a great meteor fell in the north of Asia, in the part known as Siberia. When it hit the solid part of the earth, the explosion was so great that the forest in which it fell was burned for a distance of 25 miles from the meteor. But there is no need to worry about a large meteor falling near you.

Think of how many meteors enter the earth's atmosphere each day. Now think of how very few are larger than a small pebble.

No one has ever been hurt by a meteor so far as we know. Almost all meteors are burned up completely before they ever reach the solid part of the earth.



## Comets Visit the Earth

Another interesting kind of visitor to the earth is the comet. The word *comet* comes from a Greek word meaning "long-haired." These bodies were probably named comets because their long tails reminded people of long hair.

The most famous comet to visit the earth is Halley's comet, which is shown above. This comet last visited the earth in 1910. It should visit the earth again about 1985. You will very likely see this large and beautiful comet then.

Halley's comet was named for an English astronomer, Edmund Halley, although he did not discover it.

Halley learned much about comets by watching the one that has since been named for him. He was able to figure out its path around the sun. He did this in 1682, when the comet visited the earth.

Halley predicted that the comet would again visit the earth in 1758. Sure enough, the comet appeared that year. It was also predicted that the comet would reappear in 1835 and in 1910. And it did!

Halley's comet had been seen many times before he was born. It was seen through the years at certain times. It was seen long before Christ was born.

It is interesting to know that Halley was able to work out the path of the comet very exactly. He was so careful in his work that he predicted the return of this comet to the earth once about every 75 or 76 years.

The path of a comet is not so nearly a circle as is the path of a planet. Paths of comets are oval, or egg-shaped. In the picture below notice the difference between the earth's path and that of a comet.

Comets seem to be made of bits of dust and gases. As a comet comes nearer the sun, its tail gets longer and longer. This change is probably due to the effect of the sun's bright light.

Light from the sun pushes gases out of the head of a comet. This causes the tail of the comet to be longest when the comet is nearest the sun.

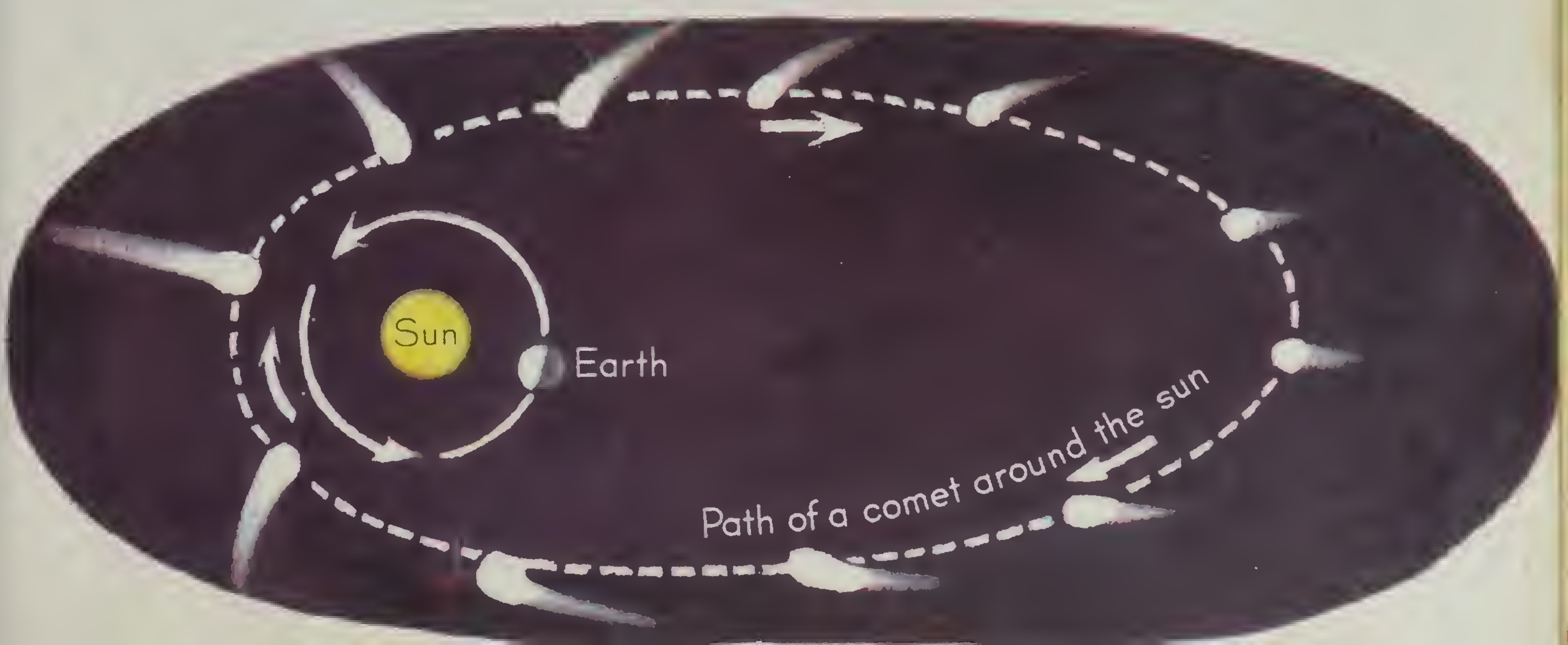
Notice that no matter where the comet is in its path, the head is always toward the sun. The tail is always away from the sun. This shows that light pushes gas away from the head of a comet.

Some comets have heads that are thousands of miles in diameter. The tails may be many millions of miles long. But the heads and the tails are very thin. A comet's tail is so thin that stars may be seen at night through it.

If the earth ever ran into the head of a comet, probably nothing would happen except that there would be many meteors falling. In 1910 the earth passed through the tail of Halley's comet. The sky seemed a little brighter when this happened.

Over a thousand comets have been seen. Most of them are small. Some have short paths. Many are seen regularly.







# Beyond the Sun's Family

We have been thinking about the many interesting planets, moons, comets, planetoids, and meteors that are members of the sun's family. The sun and its family are members of a much larger family.

The sun is a star. It is only one of billions of stars. We can see only about 3000 stars on a night when there is no moon. With a telescope many, many more may be seen.

Where are all these stars? Did you say, "Why, up in the sky"? Yes, that is exactly where they are—up in the sky.

Let us think of what we mean by "up." In the picture on the left above, all the children are pointing up in the sky. The boy in South America is pointing up just as much as the other children are.

Another way of saying "up" is to say "away from the earth." Stars are away from the earth in every direction. That is why stars may be seen, no matter where we are on this big, round earth.

If "up" is away from the earth, then "down" must be toward the center of the earth. And so it is.

The boys and girls in the picture on the right above are pointing down. They are pointing toward the earth's center. So we could say "down" is toward the center of the earth, no matter where we are on this big, round earth.

Millions and millions of stars! The nearest star is the sun, about which we revolve. But there are many others far up in the sky, all around the earth.

# Changing Ways of Finding Out

Ancient peoples watched the sky. They saw that the sun rose in the east each day and set in the west. They watched the moon's phases. These happenings could not be explained very well. So the people sometimes became frightened of the sun and the moon. They were especially frightened when the sun and moon were eclipsed.

The falling of meteors frightened ancient peoples, too. Some of them thought pieces of the sun were breaking off and falling to the earth. You can imagine how comets affected these people.

There were no instruments, such as telescopes, to be used for studying the sky. There were not many records to help them understand the happenings of the past.

So from very early times people feared and worshiped the sun, the moon, and the planets. Many groups of early people thought that each of these bodies was a god or a goddess.

The early Greeks thought the sun was a god riding in a great golden chariot across the sky. This young and beautiful god they called Apollo. The light from Apollo and his chariot was thought to be healing.

The early Romans thought the moon was a goddess. This beautiful young goddess, Diana, was supposed to be the goddess of the hunt. If one asked Diana to help, one might have good hunting.

Diana was thought to use a bow and arrow. Think of the shape of a crescent moon. Can you understand why the early Romans thought the moon was Diana?

Only five planets were known to early people. Uranus was not discovered until 1781. Neptune was discovered in 1846, and Pluto in 1930. Only the planets Mercury, Venus, Mars, Jupiter, and Saturn can be seen without a telescope.

It was noticed by the early people that these five planets moved in the sky during the night. They moved faster than any other bodies except the moon and meteors.

So these people came to know that there was a difference between these five bodies and all the stars. These bodies came to be known as planets. The word *planet* comes from a Greek word meaning "wanderer." These five bodies seemed to wander among the stars, and so they were called planets.

The Greeks thought each of the planets was a god or goddess. They had their own names for them. The names we use for the planets came from the Romans, who also thought planets were gods or goddesses.

The Romans thought Mercury was a young god. Since Mercury moved swiftly, this planet was the messenger god. Venus was the goddess of love and beauty.

Mars was the god of war, and so the reddest of the planets was thought to be Mars. Jupiter was the greatest of the gods, and Saturn was the god who protected all growing things.

Ancient peoples all over the earth feared and worshiped bodies in the sky. They did not have ways of finding out the truth about the moon, sun, stars, planets, comets, and meteors.

# First, We Used Our Eyes

Very early people spent much time out of doors. They raised plants for food. They hunted animals for food. Shepherds tended their flocks of sheep. Day and night they used their eyes in watching the sky.

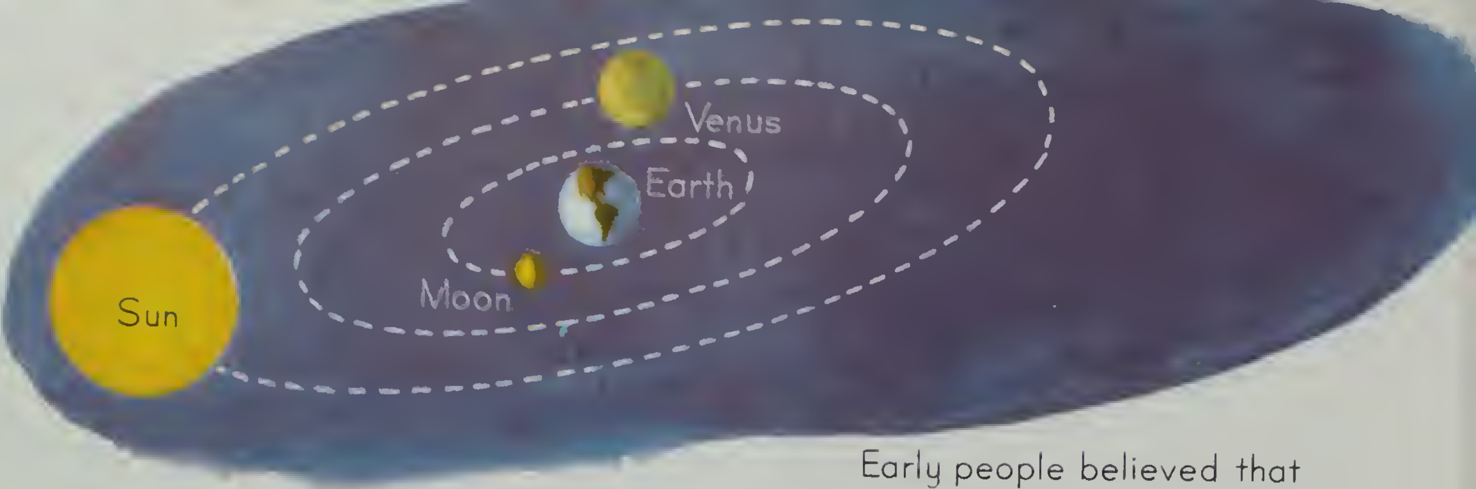
People who lived in Babylon more than 4000 years ago also watched the sky very carefully. They knew that the sun rose in the east each day, but they also knew it rose in a different place in the east each day.

Year after year they noticed this. They knew that on the longest day in the year the sun rose farthest to the north in the eastern sky. So they built their main street in such a way that the sun shone straight down on it all day on this one day in the year.

Early Egyptians worshiped the bodies in the sky also. Egyptian priests, such as the one shown in the picture below, were responsible for watching the sky very carefully. They believed that they could tell the future if they watched the movements of the stars, moon, sun, and planets.

Egyptian priests began to keep records of the movements of the stars. One of these records was started more than 3000 years ago.

The king of the Egyptians depended on the priests a great deal. They were the ones who helped him to plan what he should do.




Early people believed that
all sky bodies moved around the earth

The Egyptian priests were able to help the builders of great temples. They knew the directions north, south, east, and west very accurately. Because they knew these directions, the priests were able to help builders lay out their plans.

This was especially true in building temples or tombs. Often these buildings were planned so that their four sides faced exactly to the north, east, south, and west.

The pyramids of Egypt were built as tombs for kings, queens, and other noblemen and noblewomen. The largest of the pyramids was built about 4500 years ago.

As early as this, Egyptian priests studied the stars carefully. They were able to help the builders of this huge tomb make a hole in it from the very top down into the room where the king lay.

Down this long hole, or shaft, shone the light from one star. And that star was a very particular star. It was the North Star.

People believed for many, many years that the earth was the central and most important body in the sky. They thought this because they knew most about the earth.

Also, they thought that all the other bodies in the sky moved about the earth, as is shown in the picture above. This was believed by most people until only about 450 years ago.

It is interesting to know that a Greek living more than 2000 years ago believed the earth revolves about the sun. Very few people believed this man, though. Their eyes seemed to tell them that the sun moves about the earth. So they believed this.

# Then We Used Our Eyes and the Telescope

About 480 years ago in Poland was born a baby who was to change the thinking of many people. The baby was Nicolaus Copernicus.

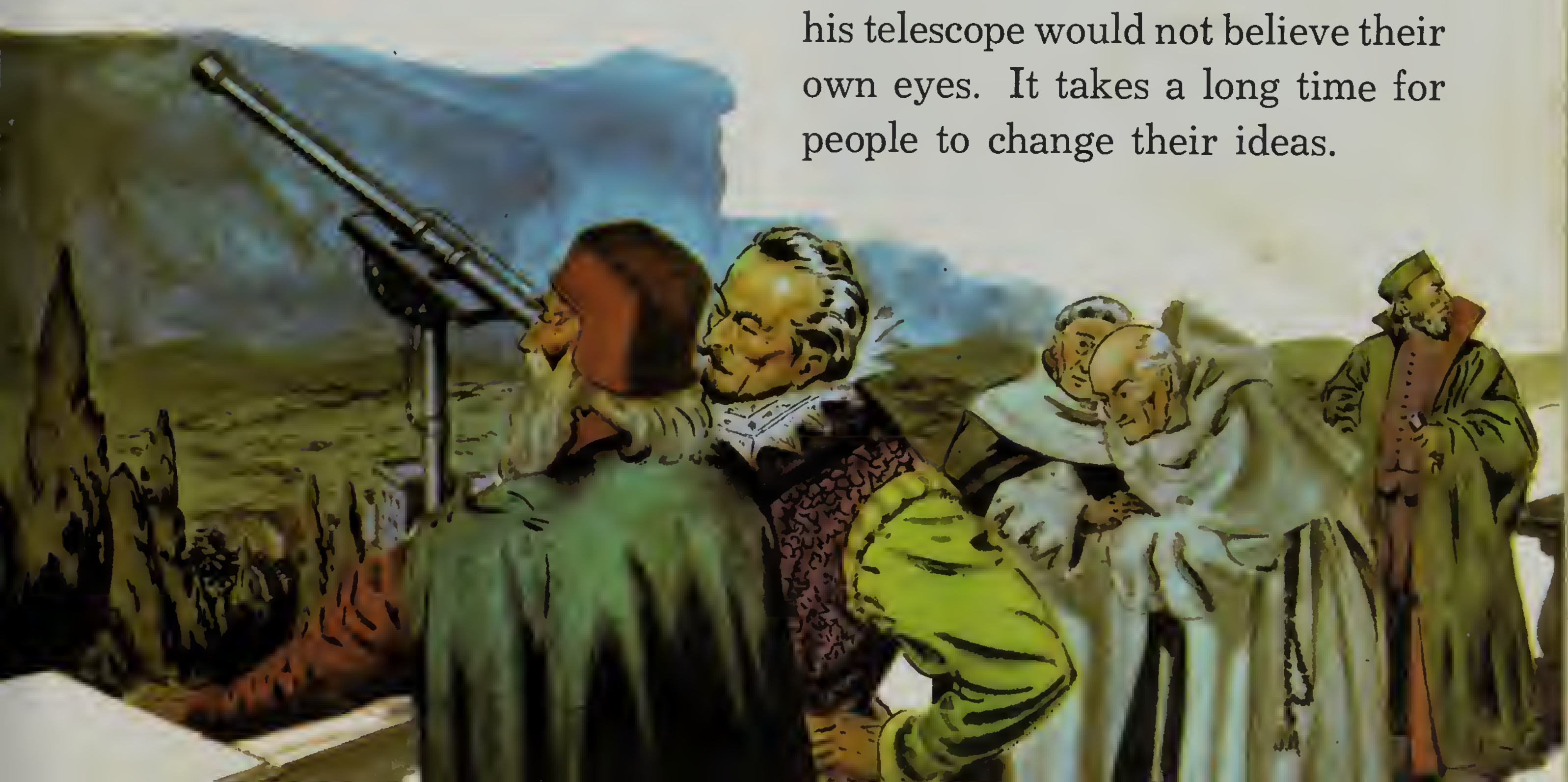
As he grew to manhood, Copernicus became interested in studying the bodies in the sky. He could not watch these bodies very well, because his eyesight was poor, and the sky was often cloudy.

But Copernicus spent much of his time in reading and thinking about stars and planets. Finally, he decided that he could not believe that the sun and planets revolved about the earth. He believed that the planets revolve about the sun. Copernicus worked out his belief very carefully, but few people listened to him.

For many, many years only the eyes of people could be used in seeing sky bodies. Certainly no one could see any body in the sky moving around any other body. Who could believe Copernicus?

The first person to use a telescope for sky study was Galileo, who lived in Italy. On January 7, 1610, Galileo saw a most wonderful sight. He saw three of the moons of Jupiter! On January 13 he saw a fourth moon. Galileo watched these moons for several nights. He saw them revolving about Jupiter. Here were bodies which did not revolve about the earth. Here was the first real support for the ideas of Copernicus.

But people did not believe Galileo either. Some who looked through his telescope would not believe their own eyes. It takes a long time for people to change their ideas.



# Now We Use Eyes, and Telescopes and Other Instruments

Since the time of Galileo many new things about the sky have been discovered. Uranus, Neptune, and Pluto, which were unknown to ancient people, have been found. Recently some people who study the sky have said that more study may show that Pluto is not a planet at all.

About a thousand comets have been discovered. New ones are discovered each year. These new comets have been found because we have telescopes that let us see much farther into space than the telescope of Galileo let him see.

On this page is a picture of the largest telescope in the world. It is the Hale telescope at Palomar Observatory in California. The mirror at the bottom of the telescope collects light from the sky and reflects it to the astronomer's eyes.

This mirror is very large. It has a diameter of 200 inches, or more than $16\frac{1}{2}$ feet. Make a circle with a diameter of $16\frac{1}{2}$ feet out of doors or on your schoolroom floor. A mirror this large can collect and reflect much light.

But telescopes are not the only instruments that are used to study the sky. Other instruments are used to help us know the sizes of bodies in the sky. Still others are used to help us tell their distance from the earth. Cameras also are used to photograph these bodies.

There are even instruments that break up the light from stars, planets, and comets into different colors. The colors of the light given off by stars or reflected by planets are studied by astronomers. In this way some idea is gained of the materials of which these bodies are made.

But perhaps more important than the instruments themselves are the men and women who use them. These men and women are especially trained to study the sky. They are the ones who gather information, study it, and give us new facts about the sky.

## THIS IS FOR YOU

1. The moon is our nearest sky neighbor. Planets are farther away than the moon. Our sun is the nearest star. But the other stars are very, very far away.

Below is a table showing about how long it would take to travel to some of the bodies in the sky, even if you traveled 1000 miles an hour!

After you study the table, you might like to work out a way to show these facts on a large chart or a mural for your classroom.

| | |
|---|---|
| To the moon | $\frac{1}{36}$ year, or 10 days |
| To Venus | 3 years |
| To Mars | 6 years |
| To a planetoid | 20 years |
| To Jupiter | 45 years |
| To Saturn | 90 years |
| To Pluto | 406 years |
| To the sun | 11 years |
| To next nearest star | 2,800,000 years |

2. If there is a telescope in your community, plan to look through it.

3. Did you know that you can see the mountains on the moon when you use strong field glasses? Try to borrow some field glasses so that you can see these mountains.

4. We believe the temperature of the sun is 10,000° F. Why do you suppose the hottest place on earth is only about 140° F?

5. You may be interested in tides, especially if you live near an ocean or one of the Great Lakes. Both the sun and the moon help to cause tides on the earth. Try to find out how they cause tides.

6. Suppose there should suddenly be no more sunlight. Describe your life on the earth then.

# Plants and Animals Now and Then

## Plants and Animals Everywhere

Even in the coldest places and the hottest places we find plants and animals. As we look about our town or our farm, we see that there are plants of many different sizes. Some are large; some are small. This is true of animals too.

Some plants, such as palm trees and cacti, are found growing in warm places. Firs and spruce are found in colder places. Certain kinds of mosses grow in both warm and cold places.

Alligators will be found only in warm places. And moose roam about in cold places. Mountain goats live in mountainous regions. Blue crabs live along the Atlantic coast. But we find cows and horses and dogs living almost everywhere.

Are the plants and animals that live in your part of the country much the same as the plants and animals in another part of the country? Do certain plants and animals live in another part of the country and not in your part?

# The Time of Ancient Reptiles

Looking about wherever we live, we see many different kinds of plants and animals. Make a list of some of the plants and animals you have seen in your community.

Ask your teacher if the same kinds of plants and animals lived here when she was a little girl. Ask your father and mother about this. Ask your grandmothers and grandfathers to tell you about the plants and animals that they knew when they were girls and boys.

You may find that the plants and animals living in a certain community have been living there during all these years. But there may be some changes.

If your community has more houses, factories, and stores than it once had, there may not be as many plants or animals. But those plants and animals living there today are probably of the same kinds as those that lived there when your grandparents were children.

Is there a river or stream near where you live? Do you go fishing or swimming there in the spring and summer?

Ask the older people whom you know if this stream is a new stream. Ask them if they fished and swam there when they were children. Or perhaps there is no stream today where there once was one.

Are there hills or mountains near your home? Ask if these hills or mountains have been formed recently. You will find that the hills and mountains are today much as they were a long, long time ago.

Sometimes we build a dam across a stream. This may make a lake where one has never been.

But as you ask questions about the part of the country where you live, you will find that the land and the living things are much as they were when your grandmothers and grandfathers were young. Are there farms with cows and horses? Are there trees? Are there hills, rivers, animals, and plants?

Suppose you could see the place where you now live as it was long, long ago. This would be many, many, many years before your grandmothers and grandfathers were girls and boys.

It would be many years before their great-great-grandmothers and great-great-grandfathers were girls and boys. If you could see your community as it was then, it would probably look very different.

The picture above shows some of the plants and animals which may have lived many thousands of years ago in Alberta in the region now known as the Badlands, near Drumheller. The plants and animals living there then were not at all like the ones living there today.

Long ago huge fern trees were growing there. These huge fern trees could grow so far north because the climate in Alberta was much warmer at that time.

There were no winter snows, no cold, no icy winter winds. The days were warm all year long. Much warm rain fell on the land.

The warm climate caused the land to have many swamps. It would not have been a good place for farms. It would not have been a good climate for many of the plants and animals of Alberta today.

But it was a good climate for some of the strange animals living then. The climate and the land and the plants made a perfect home for reptiles.

Reptiles such as snakes, lizards, and turtles live in Alberta today. But the ancient reptiles were different from these.

# Dinosaurs

*Dinosaur* is the name which is given to some of the ancient reptiles. So far as we know, no men or women or boys or girls lived at the time dinosaurs lived.

As a matter of fact, we know about these ancient reptiles because their bones have been found. Many of the bones of dinosaurs have been found in stones.

Sometimes only the footprints of dinosaurs are found. These footprints were made in soft mud. The soft mud later changed into stone. Perhaps there is a museum nearby which has a collection of dinosaur bones and footprints in stone.

Some of the dinosaurs were very large. You can see how large some were by comparing the boy and girl with the large *Tyrannosaurus rex* on the left. The *Brontosaurus*, on the opposite page, was even larger.

*Tyrannosaurus rex* means "king of the tyrant reptiles." Indeed, it was a tyrant. This dinosaur was a meat-eating animal. So it hunted other dinosaurs for food.

*Brontosaurus*, the "thunder reptile," was a very large dinosaur. But it was not very fierce. *Brontosaurus* was a plant-eater and lived in the swamp, where there was much food.

Other kinds of dinosaurs were small, even when they were grown up. Some of them were about as large as a cow. Others were no larger than a chicken!

Tyrannosaurus rex

Stegosaurus

No one knows what color the dinosaurs were, since none of their skin has been found. We do know that some dinosaurs had scales or a scalelike skin.

We know this fact about dinosaurs because prints of their skins have been found. These prints were first made in soft mud. This mud later changed to stone.

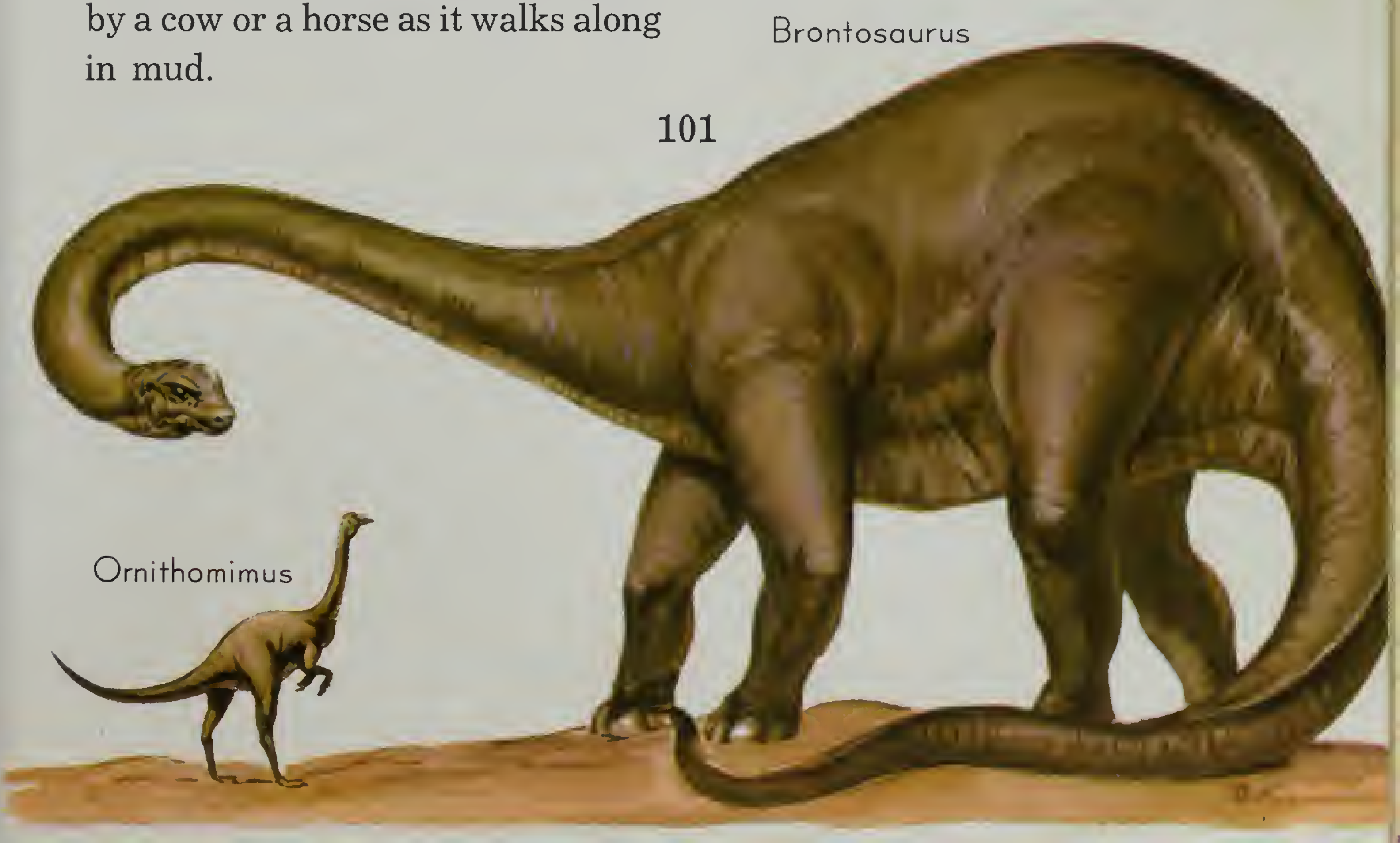
Some reptiles today have scaly skin. Some snakes have scales, and turtles have scalelike skin on their necks and legs.

Other prints made by dinosaurs tell us other things about them. We know that some dinosaurs walked on four legs. They left prints that look something like the prints made by a cow or a horse as it walks along in mud.

Prints made by other dinosaurs show that they walked on only two legs. Sometimes the print of a dinosaur tail is found. The print was made because the dinosaur dragged its tail on the ground as it walked along.

Some dinosaur footprints are so far apart that you probably could not jump from one to the other. The dinosaurs that made these footprints were large and took long steps.

Other dinosaur prints look very much like chicken tracks. The dinosaurs leaving such footprints must have been small in size and light in weight.



No one knows how many different kinds of dinosaurs there were. On these pages are drawings of some that once lived. The bones of dinosaurs give us some idea of the way these animals may have looked.

The bones of some dinosaurs show that they could fly. These animals did not have feathered wings, such as birds have. Their wings were more nearly like those of bats. Probably the wings were made of bones with thin skin stretched between them.

These flying dinosaurs had sharp claws on their feet. They also had claws on each wing. These four sets of claws helped the dinosaur to cling to rocky cliffs. They probably were also useful in getting food.

Other dinosaurs had no feet. They had flippers, which helped them to swim. These swimming dinosaurs lived in lakes. They had long necks. Probably they could dive and reach down into a lake for food.

The very large, heavy dinosaurs often lived in swamps. They could move around easily there because the water helped to hold them up. It is thought that these dinosaurs ate plants.

Yes, there were many, many dinosaurs. There were many different kinds of dinosaurs. But no man or woman or boy or girl ever saw a live one.



# No Dinosaurs Today

Today you could travel all over the world without finding a single living dinosaur. The last dinosaur died thousands of years ago.

We say that dinosaurs are extinct. This means that none of them live today anywhere in the world.

Try to think of some reasons why dinosaurs have become extinct.

Some of your reasons may be right. No one can tell you whether all your reasons are right or wrong. No one knows why dinosaurs became extinct.

Dinosaurs probably became extinct because of changes in climate. Let's think about how changes in climate could cause animals to die.

Dinosaurs were reptiles. All reptiles are cold-blooded animals. This means that their blood is about the same temperature as the air or water around them.

If it is a hot day, let us say 92 degrees, the blood of a reptile is just about that warm. If the air is only 23 degrees, the blood of a reptile grows cold and might even freeze. This would cause the reptile to die.

Some people think that the winters became so cold that these large reptiles could not live through them. They could not travel to a warm place, because they were so awkward. Many of them could not burrow in the ground, as reptiles do today. They were too large.

Other people think that the climate became very dry and that the swamps dried up. Year after year there was less and less food. Then the dinosaurs began to die out.

Changes in climate may have caused dinosaurs to become extinct. But no one knows exactly why these animals became extinct.



# The Time of Mastodons

The earth grew colder and colder each year. Winters became colder each year. Summers became colder each year. Every place on the earth became colder.

Each year the summer was only a little colder. Each year the winter was only a little colder. But changes took place for hundreds and hundreds of years until both summers and winters were cold.

Finally, both winters and summers were very, very cold. Because of this, great sheets of ice and snow covered much of the land.

Then most of the animals of the earth lived on the part of the earth that we now call the tropics. Even in the tropical part of the earth, it was not warm all year round. The tropics of today had cold winters and cool summers then.

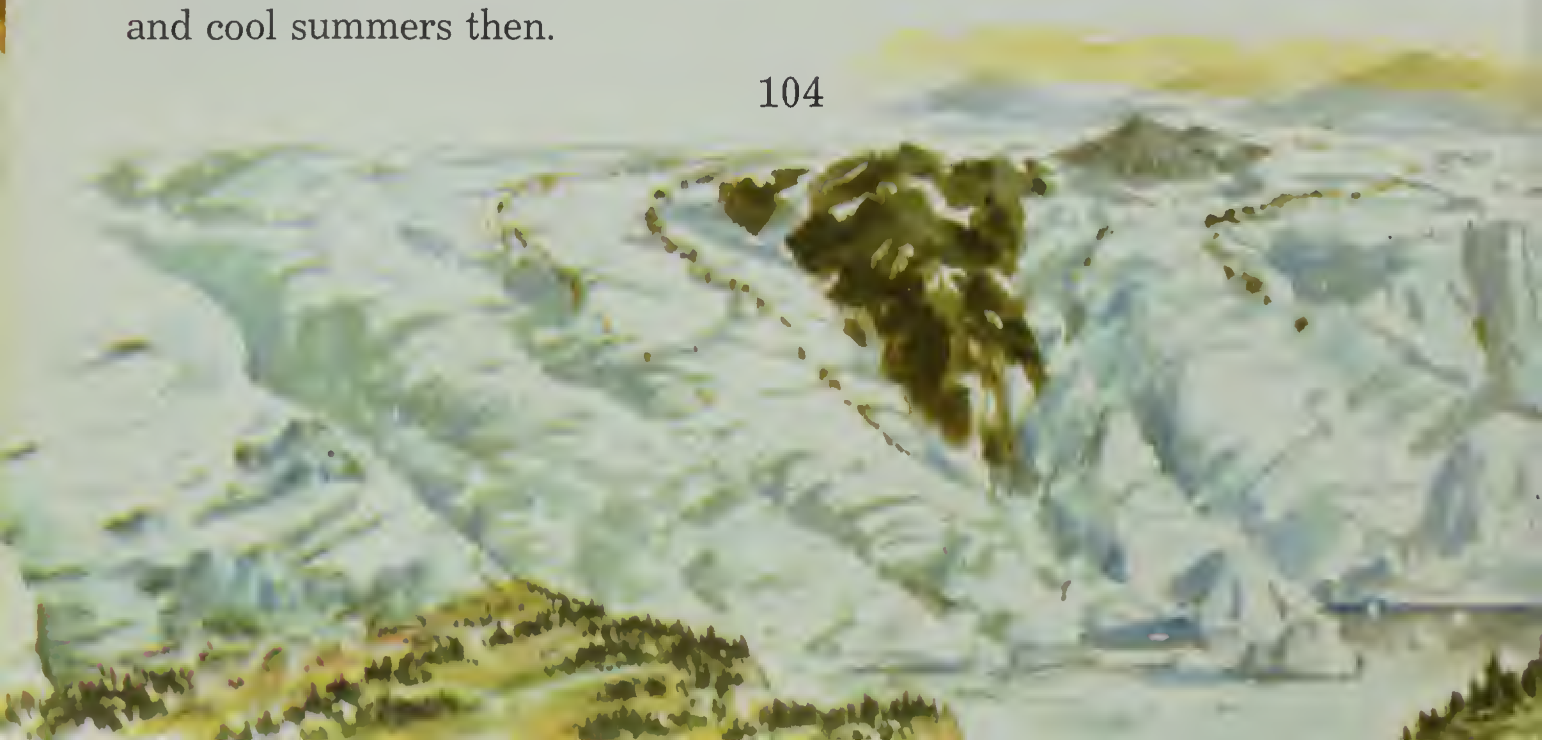
Many kinds of animals that had once lived in the far north or the far south now lived in this warmer part of the earth. As you know, the far northern and far southern parts of the earth had been quite warm during the time of the dinosaurs.

But the climate of the earth became more and more different each year. Finally, sheets of ice hundreds and hundreds of feet thick covered much of the land.

These sheets of ice were thicker than the tallest building in your city is tall. The ice sheets were even thicker than the very tallest building on the earth is tall.

Great sheets of ice such as those that covered the land are called glaciers.





Glaciers cover parts of our earth today. There are glaciers on high mountains in many parts of the earth. A glacier covers almost all of Greenland. A huge glacier covers much of the land around the south pole.

Animals are able to live near the edges of such glaciers. But the animals must be able to live through very cold winters and cool summers.

One of the kinds of animals that lived near glaciers long ago was the mastodon. As you can see from the picture below, mastodons looked a little as our elephants do today.

But mastodons were much better suited to a very cold climate than our elephants are. Their bodies were covered with long, shaggy hair. This was a protection against the cold winds.

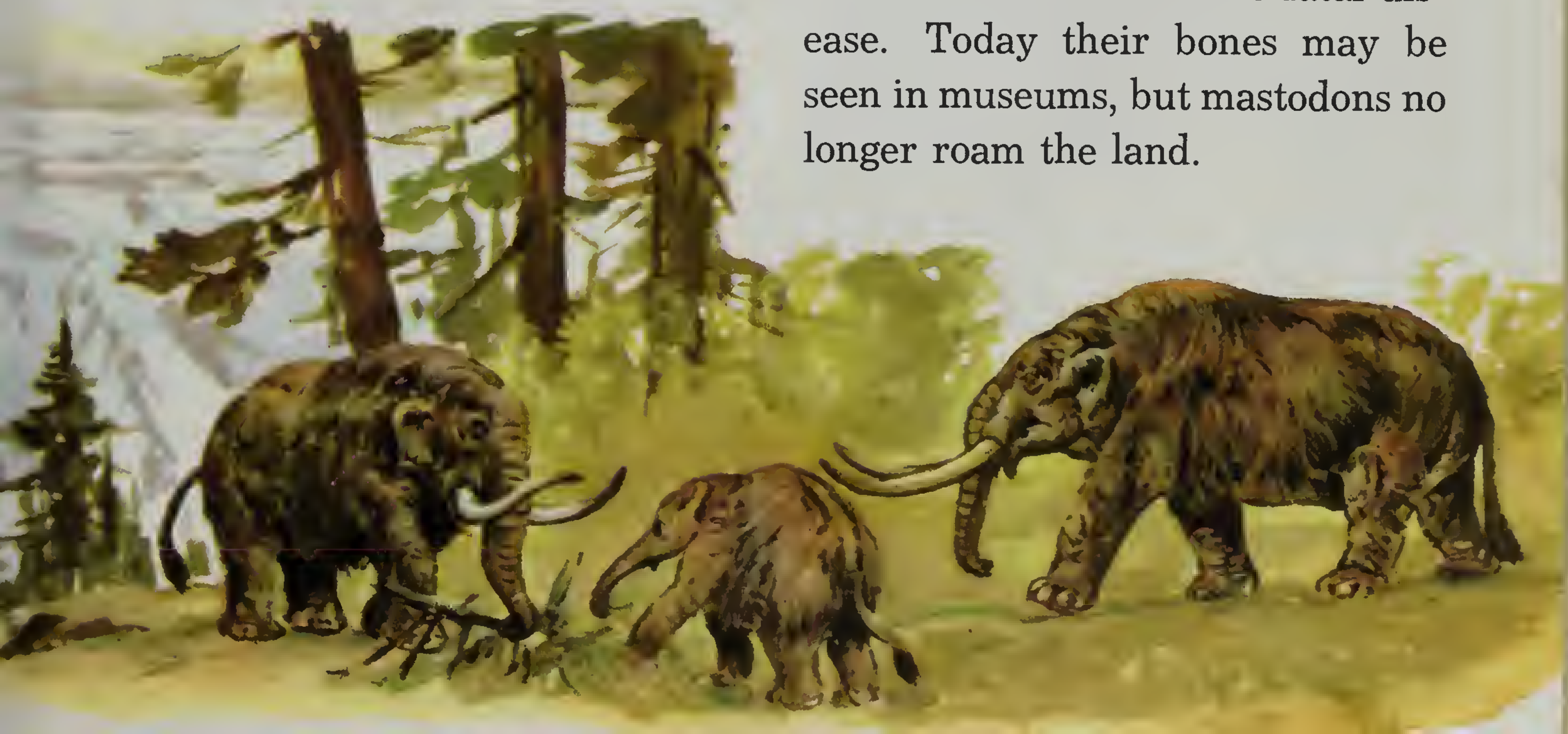
Mastodons were warm-blooded animals. This means that their blood remained at about the same temperature all the time, just as the blood of people does.

Dinosaurs were different. They were cold-blooded animals. The temperature of a cold-blooded animal changes with the temperature of the air or water around it. Think of why dinosaurs could not have lived near the great glaciers.

But the mastodons were well protected. Their temperature remained about the same all year round.

Mastodons are now extinct. They no longer roam the earth—even in the cold lands far to the north and far to the south.

Why did mastodons become extinct? Perhaps they were attacked by their enemies. Or they may have died out because of some fatal disease. Today their bones may be seen in museums, but mastodons no longer roam the land.



# Stories in Stone

Stories are not always told in words. Sometimes they are told in pictures. Sometimes they are told by watching plants or animals in the out of doors.

Stories are also told in stone. If you have ever seen the print in stone made by a plant or an animal, you have read a part of its story.

Prints were made in mud or sand. The mud or sand long ago changed to stone. Men and women who were able to read the story told in the stone placed it in a museum.

Look at the pictures at the top of the next page. What story do they tell you?

The first picture tells that once there grew a plant with leaves of a certain shape. Here in the stone is the print of the leaves.

The second picture tells that once there lived an animal with a shell of a certain shape. Here is the print of the shell of that very animal.

Sometimes a good place to find stories in stone is at a quarry. But very often a person who has studied the stones is needed to help us read the story.

A limestone quarry or a sandstone quarry or a shale or slate quarry may have stories to tell of plants and animals that once lived.



Limestone is formed at the bottom of a sea. So you might expect to find bones and prints of sea-dwelling animals in such stone.

Sometimes limestone is pressed by soil or water which covers it. If it is pressed too much, the prints or bones are smoothed out. Then they can no longer be seen.

Sandstone was once sand. Such a stone as sandstone might also have bones or prints of animals and plants in it. But again, if the sandstone was pressed too much when it was hardening, we might not be able to find prints in it today.

If there is a sandstone or limestone quarry near you, plan to visit it. Be sure to ask someone to go with you to help you read the story told there. Some people make a business or hobby of stories told in stone.

Perhaps the man in charge of the quarry could help. Or perhaps your father or mother or your brother or sister has this hobby.

But suppose the stones of your quarry have no bones or prints in them. You might think that no story could be read from such stones. This would not be true. If you learn what kind of stone is being quarried there, you know part of the story.

If the quarry you visit is a limestone quarry, you know that once a sea was in this place. The sea was there hundreds and hundreds of years ago.

A shale or slate quarry also tells a story. Both shale and slate were once mud. So we know that this place was once a sea or lake or swamp with a muddy bottom.

Suppose the quarry is a sandstone quarry. Sandstone was once sand. So this place where you now visit may once have been a beach.

Perhaps the quarry you visit is a granite quarry. Such a quarry tells an interesting story indeed. Granite is a rock that was first formed deep in the earth.

If the granite in the quarry was formed deep inside the earth, how is it that we now find the granite near the top of the earth?

Here is one explanation: Perhaps there were great movements of the earth. The land was pushed upward. So the granite was moved toward the surface of the earth. Then rain washed away the soil year after year. Finally, most of the soil was washed away from the granite. Now the granite is at or near the surface of the earth.

Yes, even a sand pit has a story to tell. It tells of a beach which is no longer here.

Any or all of these stories in stone tell us the same thing. They tell us that the earth changes.

Plants and animals that are now extinct once lived on the earth. We know of them by the prints and bones that are left. Once there were seas and lakes where there are none now. Once there were greater ice sheets than there are today.

Our earth has changed greatly!

## THINKING ABOUT YOUR COMMUNITY

1. No matter where you live, your community has a story to tell in its stones and soil.

Make a museum in your own classroom. This museum might show the stories about your community that stones have to tell.

Perhaps someone in the neighborhood has a collection of stories in stone that would tell more about your community.

Try to arrange a visit to see this collection. Or ask the owner if he could visit your class.

2. Most people like to watch the construction of large buildings. One of the most interesting parts is digging the basement.

Not so long ago a basement was being dug for a large building right in the downtown section of the city of Boston. The men discovered that the ocean had once covered the place where they were now digging.

They knew this because they found the posts that Indians had once used for holding their fishing nets. These posts were covered by dirt and stones which had been washed into that part of the ocean.

You might not make such an exciting discovery in your community. It would be interesting, however, to find what kinds of rock and soil lie under the ground. Perhaps you will be able to add to the story of your community if you study the layers of soil and stone.

3. The story of the way your community once looked would make an interesting mural. Or you could make a series of pictures on a long strip of paper. Fasten a round stick to each end of the strip and roll it into a "movie."

Perhaps you could make a scene like the one above. This kind of scene is called a diorama. It may be made in a large box. Use a piece of heavy paper for the background scene. Plants can be made from twigs and bits of colored paper. Animals can be made of clay.

4. Whatever you tell in the story of your community, it will be a story of change. Your story may tell of a sea or a desert or a great forest which once covered the land. It may tell of animals or plants that could not live successfully there.

All over the earth, animals and plants and land have changed.

# Chemicals Everywhere

## Some Common Chemicals

Have you ever wondered what the things you see about you are made of? Perhaps you have said that this thing is made of metal. Or you may have said that thing is made of cloth or of rubber or of plastic.

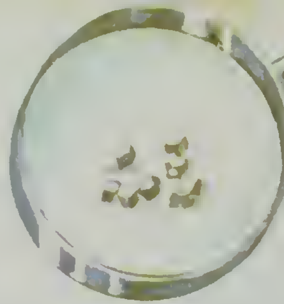
You may have said that this thing is made of wood or that thing is made of steel. Or perhaps you have said this is made of flour and sugar and butter and milk.

If you said these things, you were probably right. But you could have said that every one of these things is made of chemicals.

Everything on the earth is made of chemicals. Even the earth is made of chemicals.

Study the picture on these two pages. Make a list of the things you see. Each thing on your list—the boy, the girl, the dog, the smoke, the clouds, the kites, the trees—is made of chemicals.

Diamond



Sugar

Salt

Quartz

Copper

Gold

Mercury

Water

Let's name some of the common chemicals which you see or use every day. Sugar, salt, quartz, gold, copper, and water are common ones. Sugar, salt, quartz, and water are each made of more than one chemical. But first, let's think of substances which are made of only one chemical.

You may have used copper when you used a copper wire to make an electric circuit. You have certainly used copper when you put a penny in a machine to buy a piece of candy or gum. A penny is part copper. Copper is a chemical. But of what is a piece of pure copper made? A piece of pure copper is made only of copper.

If you could take a piece of pure copper entirely apart, the smallest piece of copper would be very, very small. It would be so small that you could not see it, even with the most powerful microscope. That smallest piece of copper would be called an atom of copper.

Now let's think of what gold, mercury, and diamonds are made of. Gold is made of gold. The smallest piece of gold is an atom of gold. Mercury is made of mercury The smallest piece of mercury is an atom of mercury. A diamond is really pure carbon. And the smallest piece of carbon is an atom of carbon.

About one hundred of these basic chemicals are known. They are called elements. Each element is made only of itself. The smallest piece of any one of these elements is an atom of that element.

At the bottom of this page is a list of some of the elements. Beside each element are one or two letters. These letters are the symbol, or short name, for each element.

For instance, the symbol for the element argon is A. Look at all the symbols. Do some of them seem rather strange to you?

The symbol for the element gold is Au because the Latin word for gold is *aurum*. The symbol for the element iron is Fe because the Latin word for iron is *ferrum*. Use a dictionary to find out why copper, lead, mercury, silver, sodium, tin, and tungsten were given their symbols.

Many of the elements were known and used by early man. But several new elements have been made recently. Scientists have made these by using elements known earlier. But as yet, not all the new elements have been found in the ground or in the water or in the air.

Neptunium and plutonium are elements which were made by man. These elements are used to give us atomic energy. Some other new elements are americium, curium, californium, and berkelium.

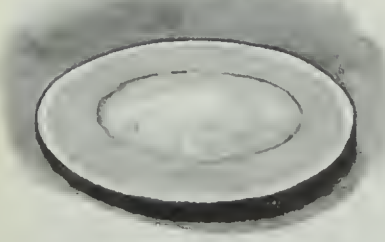
Think why these elements were given these names. Here are some hints: Madame Curie was a famous scientist. What are the two planets farthest from the sun? The city of Berkeley is in California.

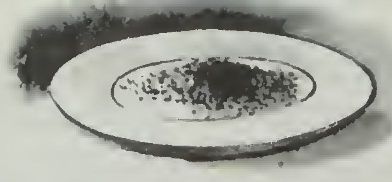
Most things on the earth are made of two or more elements which are put together chemically This is true of the sugar which you put on your cereal. Sugar is made of carbon, hydrogen, and oxygen put together chemically.

Salt is made of sodium and chlorine. Quartz is made of silicon and oxygen. Water is made of hydrogen and oxygen. Each chemical made of two or more elements is called a compound.

SOME OF THE ELEMENTS AND THEIR SYMBOLS

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| aluminum | Al | chromium | Cr | iron | Fe | oxygen | O | sodium | Na |
| argon | A | copper | Cu | lead | Pb | phosphorus | P | sulfur | S |
| bismuth | Bi | gold | Au | mercury | Hg | platinum | Pt | tin | Sn |
| calcium | Ca | helium | He | neon | Ne | radium | Ra | tungsten | W |
| carbon | C | hydrogen | H | nickel | Ni | silicon | Si | uranium | U |
| chlorine | Cl | iodine | I | nitrogen | N | silver | Ag | zinc | Zn |





# Taking Mixtures Apart

All of us have put chemicals together in different ways without realizing we were putting them together. Let's think of some ways in which chemicals can be put together and taken apart.

Do you like cinnamon toast? If you have put sugar in a dish and added cinnamon to it, you have made a mixture of chemicals. This is a very pleasant mixture, especially when we eat it on buttered toast.

How would you take this mixture apart? It might take you a long time, but it wouldn't be very difficult. The sugar is white, and the cinnamon is brown.

You could look at your pile of cinnamon sugar under a magnifying glass. Then you could put all the white pieces in one pile and all the brown pieces in another.

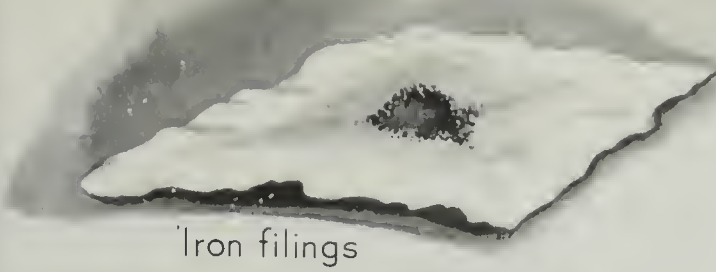
Cinnamon sugar is a mixture of chemicals. This mixture can be taken apart easily.

Now suppose you make some mixtures of chemicals and take them apart. You will not need to use harmful chemicals or chemicals that might burn your hands. The chemicals we shall use are harmless, and you will be able to get them quite easily.

Before starting to do a chemical experiment, be sure you have all the necessary materials.

For the first experiment you will need salt, iron filings, water, a measuring cup, a teaspoon, a small glass, and a paper towel. If you do not have these things at school, you will be able to bring most of them from home.

Iron filings may be a little more difficult to get. But very often they can be obtained from a machine shop. Perhaps there is one in your neighborhood. Iron filings are very small pieces of iron that have been filed off large pieces of iron as they were smoothed.





Are all your materials ready? If so, you are ready to begin.

Put water in a measuring cup until it is one-fourth full. Add one teaspoonful of salt and one teaspoonful of iron filings. Stir the mixture.

Fold the paper towel so that it is double. Push it down gently into the small glass. Be careful that you do not make a hole in the towel.

Pour the mixture of water, salt, and iron filings on the towel. What happens? After a while a liquid has dripped through into the glass. This liquid is clear because the iron filings have been held back by the paper towel. We have separated the iron filings from the mixture.

Now let's separate the salt from the water. The way to do this is to cause the water to evaporate, or to go into the air. You can do this by removing the paper towel from the glass and letting the glass stand in a warm place for a day or so. After a while all the water will evaporate.

The salt will be left in the glass because salt does not evaporate. If you want to finish this experiment more quickly, you can heat the salt water in a pan. This will cause the water to evaporate quickly.

You have made a mixture of chemicals, and you have taken the mixture apart. You began with iron filings, salt, and water. You have iron filings and salt left. The water has gone into the air.

The water that we drink is a mixture, too. Few of us ever drink really pure water. We probably wouldn't like it very well, since we are used to the taste of a water mixture.

If you live in a part of the country where the water is hard, you know that your drinking water is a mixture. This is the reason why your mother's teakettle probably gets white inside. Some of the chemicals in the water have stayed in the teakettle when the water boiled away. The chemicals left in the teakettle are white.

Perhaps you would like to make a mixture of water and some other chemicals and then take the chemicals out of the mixture. This would leave quite pure water.

For this experiment you will need a teakettle, a rubber tube that will fit the teakettle spout, and a stove or an electric hot plate. You will also need a measuring cup, measuring spoons, a bowl, a pan, a glass, a spoon, some food coloring, salt, and water. Everything must be very clean, since you will want to taste the water during the experiment.

Into the bowl put three cups of water, three tablespoonfuls of salt, and one-fourth teaspoonful of food coloring. Stir this mixture. Now taste it. It is so salty that you probably won't have any trouble remembering the taste.

Fit the rubber tube over the spout of the teakettle. Pour the mixture into the kettle and heat it.

Arrange the rubber tube so that the free end is in the clean glass. The glass should be in a pan of cold water or, better still, in a pan of cracked ice. Study the picture below to see how your experiment should look.

Now let the water boil and boil. After a while you will see drops of water coming from the tube into the glass. These drops of water are clear. Yet the water that you put into the teakettle was colored.

When there is enough water in the glass, taste it. It isn't salty, and it isn't colored.

Let's think about what happened. You made a mixture of water, salt, and food coloring. When this mixture was heated, the water turned to steam. The salt and food coloring were left in the teakettle. Steam came through the tube and into the glass. When the steam was cooled, it became water.

# Separating Other Mixtures

As we have said, drinking water is a mixture of water and other chemicals. Mixed with the water there may be several minerals, but air is also mixed in the water.

In a simple way you can show that air is in water. Fill a glass with cold water and set it in a warm place. Soon you will notice tiny bubbles on the sides of the glass.

These are air bubbles. The air that is mixed with the water is being separated from the water. When water is boiled, air is driven out of the mixture very rapidly.

Your mother often makes mixtures of air and something else. When she beats egg whites, she is mixing air with the egg whites.

When she adds water to frozen orange juice, she is making a mixture. Then she makes still another mixture by shaking the orange juice in a closed jar.

Some of the air in the jar will mix with the liquid. She sometimes shakes the jar as many as fifty times. This makes the juice taste better to us because we like juice and water with air mixed in them.

Now let's make a mixture of sugar and water, and separate that mixture. Besides sugar and water, you will also need a small glass, thread, a screw, a measuring cup, a tablespoon, and a pencil.

Be sure that all these materials are clean. You may want to taste the sugar crystals you make.

Put one fourth of a cup of boiling water in the glass. Now add one tablespoonful of sugar and stir. Then add another tablespoonful of sugar and stir. Add eight tablespoonfuls of sugar in all.

Tie the screw to one end of the thread. Tie the pencil to the other end. The picture below should help you to arrange the string, screw, and pencil.

Set the glass aside for several days. Then you will find sugar crystals on the thread. These crystals, when they are large; we sometimes call rock candy.

# Causing Chemical Changes

As we make mixtures of chemicals, we do not cause chemicals to change. If we mix sugar and water, we do not make a new chemical. We still have sugar and water, and we can separate these chemicals quite easily.

A mixture of salt and water is still just salt and water. No different chemicals have been made. This is also true of a mixture of salt, water, and iron filings. When mixtures are made, no chemical change takes place.

But there are ways of causing chemical changes. You have probably caused chemical changes, or you have watched your mother doing this very thing.

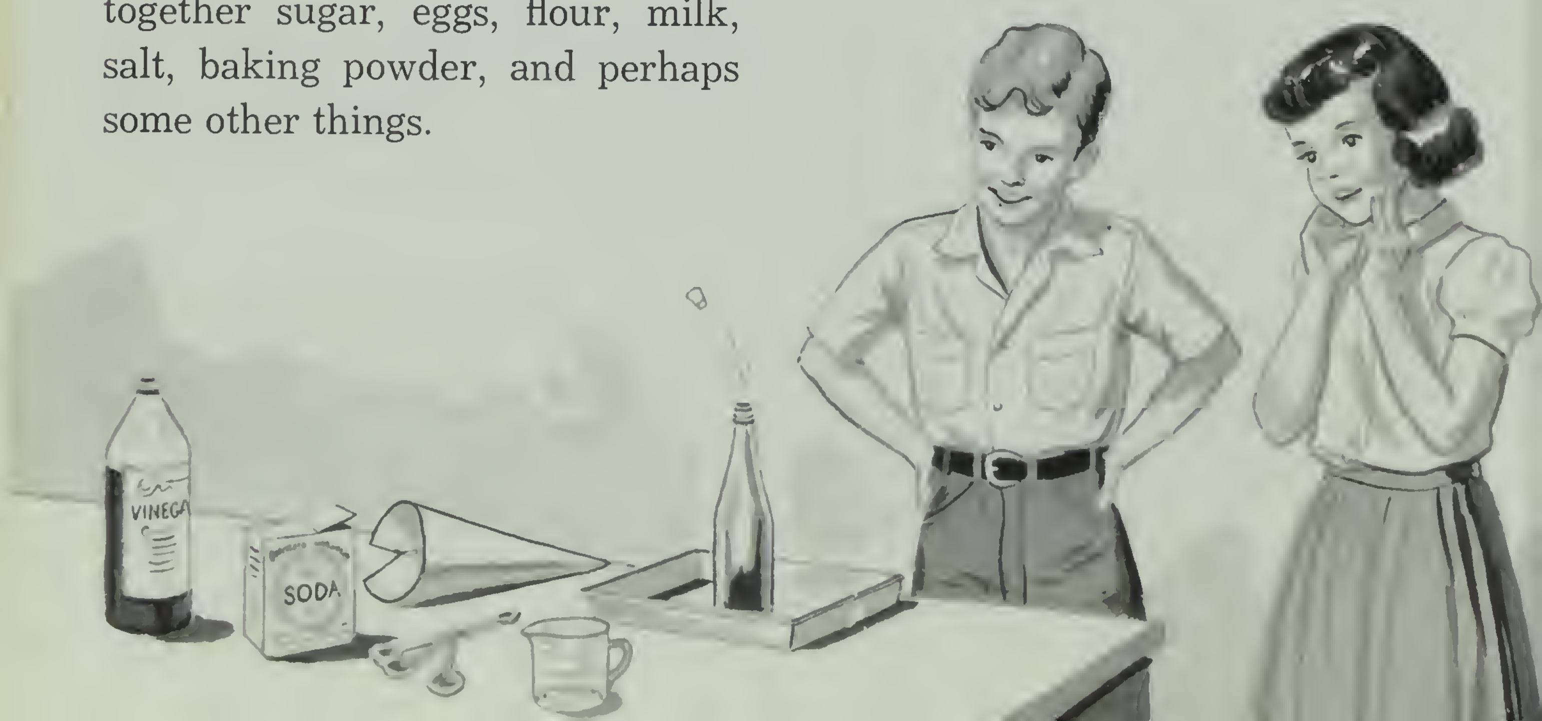
Have you ever made cookies? If you have, you know that you mix together sugar, eggs, flour, milk, salt, baking powder, and perhaps some other things.

Then this mixture of chemicals is put into the oven to bake. Several things happen to the cookie dough when it is in the oven.

The cookies puff up. They get harder. They also become brown. Baked cookies look quite different from unbaked ones. The chemicals of which the cookie dough is made have combined to make different chemicals, and the cookies look quite different.

One of the chemicals that were made was a gas called carbon dioxide. As this gas was formed in the cookies, it made them puff up.

Let's make some carbon dioxide in several different ways. For the first experiment you will need flour, water, and baking powder.



You will also need a bowl, two spoons, measuring spoons, a pot-holder, and a stove or a hot plate.

Put one tablespoonful of flour and one-half teaspoonful of baking powder in the bowl. Add just enough water to make a dough. Now put some of the dough in a teaspoon, just level with the rim of the spoon.

Hold the teaspoon over the heat. Be sure that you use a pot holder! The spoon will get hot!

Soon the dough will begin to puff up, so that it is about twice the size it was. Take the top of the dough off. Notice how soft and puffy the dough is. Carbon dioxide has been made. Tiny bubbles of carbon dioxide make the dough puff up.

The children in the picture on the opposite page have used vinegar and baking soda to make carbon dioxide.

To do this, they needed vinegar, baking soda, a pint soda-water bottle, a cork to fit the soda-water bottle, a sheet of paper, a measuring cup, measuring spoons, and a pan.

First, the soda bottle was placed in the pan. The paper was rolled into a funnel and then placed in the top of the bottle.


Then one tablespoonful of baking soda was poured into the bottle. Next one third of a cup of vinegar was poured in. Then the bottle was quickly corked, but the cork was not pushed in tightly.

The children gave the bottle a shake or two. Something was happening in the bottle. The vinegar and baking soda were foaming.

Suddenly—pop! The cork flew out of the bottle. So much carbon dioxide had been formed that the cork was pushed out.

Carbon dioxide is the chemical that has been made. It is made of the element carbon and the element oxygen. Carbon and oxygen from the baking soda and vinegar formed the carbon dioxide.

Chemists show that there are two elements in carbon dioxide by writing it in this way: $CO_2$.

Stop and think a minute about this chemical, carbon dioxide. What do you know about it? Yes, it causes dough to puff up, and it can make a cork pop out of a bottle.

Can you see carbon dioxide? No, not when it is as warm as the air in this room. But you can see carbon dioxide if it is very cold.

You have probably seen solid carbon dioxide because solid carbon dioxide is dry ice. Ice cream is often packed in dry ice. Be sure that you do not touch dry ice with your bare hands. It is so cold that it may hurt your hands badly.

So carbon dioxide can be in the form of a gas which you cannot see. It can also be in the form of a very cold, white solid.

Carbon dioxide will not burn, nor will it let anything else burn. That is why some fire-extinguishers use carbon dioxide.

Let's test carbon dioxide to show that it will not burn, nor let anything else burn. First, we will need to make some carbon dioxide. We will use different chemicals this time. Put one cup of water into a quart jar. Add one tablespoonful of cream of tartar and one tablespoonful of baking soda. Notice the bubbling as carbon dioxide is formed.

Now twist a stiff wire around a small candle. Light the candle and lower it into the jar, as the boy in the picture has done. The candle goes out. Try it again. Again the candle goes out. Carbon dioxide will not allow the candle to burn. Try this experiment with a jar of air. The candle will burn.

We have made the chemical carbon dioxide. Just think—thousands of chemicals can be made from different combinations of the different elements in the world!

# Metals Combine with Other Chemicals

Do chemical changes ever happen around your house that you wish would not happen? Is it your part of the housework to keep the silver and copper shining? Then you probably have wished that certain chemical changes would not happen.

It may seem to you that no sooner are the copper bowls and silver candlesticks polished than they begin to darken. After a few days they are ready to be polished again because they have tarnished.

When silver or copper tarnishes, a new chemical is made. When we use a silver spoon to eat eggs, the spoon often turns black. This is because sulfur in the eggs has combined with the silver.

Carbon dioxide from the air combines with copper. When this happens, a new chemical is formed, and we say that the copper has tarnished. Then the copper must be cleaned.

There is a way to keep silver and copper bright for a long time without polishing. This is done by keeping the air away from them.

Sometimes we cover our copper and silver with a liquid much like clear fingernail polish. This liquid, when it hardens, will help to keep the silver and copper from combining with other chemicals.

Iron combines very easily with oxygen in the air, especially when the air is damp. Cans made of iron are often covered with a thin coating of tin. If this coating wears off, the iron combines with oxygen. When this happens, we say that the can has rusted. Iron rust is really the chemical iron oxide.

Many metals will combine rather easily with other chemicals. Whenever they combine, a different chemical is formed.

## Burning Is a Chemical Change

Whenever anything burns, a chemical change takes place. The change is very much the same as iron rusting. Whenever anything burns, it combines with oxygen to form new chemicals.

When leaves are burning, they are combining with oxygen. When coal burns, it combines with oxygen. When oil or paper or wood burns, each combines with oxygen.

Sometimes we want a thing to burn. We like to burn trash to get rid of it. We burn wood, coal, oil, gas, or other fuels to keep warm.

But at other times we do not want things to burn, or combine with oxygen. One of the best ways to put out a wood, coal, or trash fire is to keep oxygen away from the thing that is burning. Let's try an experiment to see if this is true.

Cut three pieces of cardboard so that each is $1\frac{1}{2}$ inches square. Put a drop of candle wax on each square and set a small candle upright in the wax.

Now get a pint jar and a quart jar. Light the three candles. Lower the pint jar over one candle and the quart jar over another. Now watch. Only the candle in fresh air keeps burning.

The jars you put over two of the candles have kept oxygen away from them. Without oxygen the flames went out. Why did the candle under the pint jar go out first?

When we put sand on a fire, we shut out the oxygen. This also happens when carbon dioxide is put on a fire. Before we use fire, we should be sure that we have some way to keep oxygen away.

# Taking Chemical Combinations Apart

It is easy to separate a mixture of salt and water, or sugar and water, or salt and iron filings. When a mixture is separated into its parts, no new chemicals are made. We just put one part in one place and another part in another place.

It is harder to separate chemicals that have been chemically combined. Sugar is a chemical combination of carbon, hydrogen, and oxygen.

Carbon is an element. Some forms of pure carbon are black. The "lead" in your pencil is really a form of carbon called graphite. Soot from a fire is carbon, too.

Hydrogen and oxygen are both gases when they are at the temperature of this room. As gases, they cannot be seen, smelled, or tasted.

When carbon, hydrogen, and oxygen are chemically combined in the right amounts, they form ordinary table sugar. This sugar is a new chemical. It is not like carbon or hydrogen or oxygen. But sugar can be taken apart. Then it again becomes carbon, hydrogen, and oxygen.

However, this process is much harder to carry out than separating salt from iron filings. You can do part of the separating, but not all. For the part that you can do, you will need an old skillet or pan, heat, a tablespoon, and sugar.

Put three tablespoonfuls of sugar in the skillet or pan. Set the skillet on a hot plate or stove. Soon the sugar will bubble. After a while it will turn black.

The black powder left in the pan is carbon. Hydrogen and oxygen have gone into the air in the form of water vapor. You have separated carbon from sugar.

You can also take cornstarch apart. Cornstarch is also made of carbon, hydrogen, and oxygen. Do this same experiment with cornstarch instead of with sugar. Is carbon left in the pan?

# Heat and Light Cause Chemical Changes

We have learned to use our knowledge that heat and light can bring about chemical changes. We have learned to use this knowledge in many ways.

Have you ever noticed cloth-covered porch or lawn furniture that has been left outside for a long time? Often the cloth has become faded. The bright, hot sun shining on the cloth has brought about a chemical change in the dyes. The colors have grown lighter.

Blue cloth fades rather quickly. Show this by getting a piece of inexpensive blue cloth and putting it outside on the ground on a sunny, hot day. Hold the corners of the cloth down by placing a stone on each corner. Put a saucer upside down in the center of the cloth.

If it is possible, leave the cloth outside for two or three days. At the end of this time examine the cloth. Is it darker where the saucer and stones have been? The sun has faded the part of the cloth that was not protected.


We do not want colors in cloth to fade, but it probably was in this way that man discovered that light and heat would cause chemical changes. After he once had this knowledge, man worked to make use of it.

If you have made blueprints, you have made use of the idea that light causes a chemical change. Blueprint paper is light green before it is used. If you should dip a fresh piece of blueprint paper in water, it would be ruined. All the chemicals would wash off it.



To make a blueprint of a leaf, place the paper on a book. Then put the leaf on the paper. Next put a piece of glass over the leaf. Leave it in sunlight three or four minutes.

Now remove the blueprint paper and wash it in clear, cool water. You will find that light falling on the unprotected part of the paper has caused a chemical change. The greenish chemical on that part has turned blue. But the greenish chemical on the rest of the paper is unchanged. The water will wash it away. So the part of the paper covered by the leaf will be white; the rest of the paper will be blue.

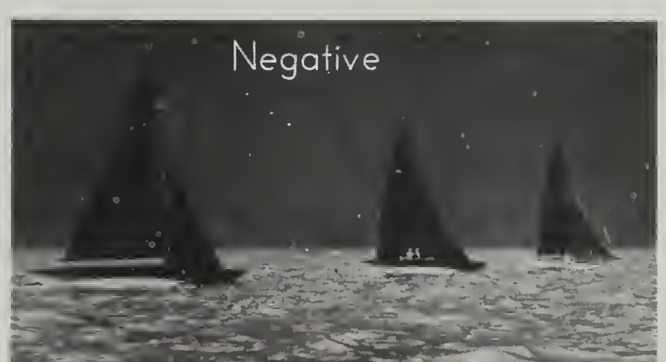
You can send secret messages because heat causes chemical changes. Squeeze some lemon juice into a small dish. Now dip the end of a matchstick into the lemon juice and write your message on white paper. Be sure to use plenty of lemon juice. Let the paper dry.

The person who gets the message will have to use heat to read it. If the paper is held above a candle flame and heated thoroughly, the message will soon appear. A brownish writing appears on the paper. Heat has caused a chemical change.

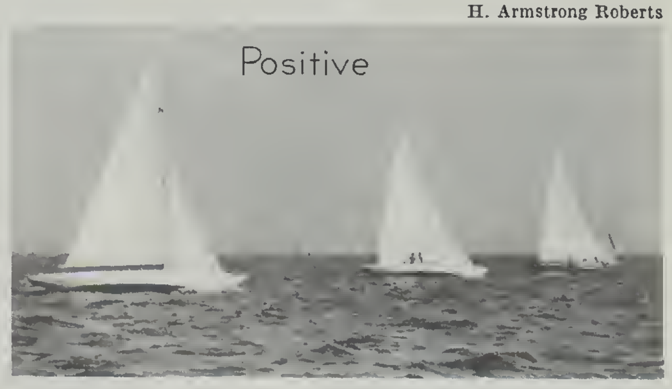
Both vinegar and onion juice can also be used to write secret messages. Onion juice on paper is brown when it is heated.

Chemical changes caused by light also help us to take pictures. One side of a film is coated with chemicals. When light strikes the film, it causes a chemical change.

When the film is developed, the places where the most light struck it are black. This film is called a negative. When a print is made from the negative, light is allowed to change chemicals on the printing paper. The print is just the opposite of the negative and is called a positive.




H. Armstrong Roberts



# What Chemical Is It?

When you want to describe how a food tastes, you often use the word *bitter* or *sweet* or *salty* or *sour*. Chemists also describe chemicals by their taste. But this is not a very safe way to tell what a chemical is, since some chemicals are poisonous.

One good way to understand more about chemicals is to try to tell whether they are acids or alkalis. An alkali is the opposite kind of chemical from an acid.

Acids taste sour, but we should not taste them, since some of them are harmful. Instead of tasting, buy some litmus paper at a drugstore. When a strip of blue litmus paper is put in an acid, the paper turns pinkish violet. But acids will not cause pinkish-violet litmus paper to change.

Dip a strip of blue litmus paper in lemon juice. It will turn pinkish violet. Test vinegar and sour milk to see if they are acids.

An alkali will turn pinkish-violet litmus paper blue. It will not change the color of blue litmus paper.

Test ammonia to see if it is an acid or an alkali. Dissolve some baking soda in water and test it.

There are certain chemicals that are neither acids nor alkalis. These are called chemical salts. Chemical salts do not change the color of either blue or pinkish-violet litmus paper. Dissolve some table salt in water and test it with litmus paper.

Suppose you wanted to know whether something had starch in it. You would test that thing with iodine. Put a little cornstarch in a saucer and put a few drops of iodine on it. The spots where the iodine touches will turn blue, showing that starch is present. Sometimes the blue is so dark it looks black.

Test white bread and a slice of white potato with iodine. Again the dark-blue spots will show that starch is present.

Sometimes we test things by heating them and watching for a color. Sodium is an element. When things that contain the element sodium are heated, we get a bright yellow flame.

Dip the end of a stick in water. Then dip this wet end in table salt. Hold that end of the stick in a flame and notice the beautiful yellow color. Table salt has sodium in it. So we get a yellow color.

Now dip the wet end of a second stick in powdered boric acid. Hold it in a flame. Notice that the flame is a beautiful green. This color is caused by the element boron. Boric acid contains boron.

Chemists sometimes use color tests when they want to find out which chemicals are in a substance. They use other tests also. Chemists are able to tell what a thing is made of by using chemical tests.

## THINKING ABOUT MAN'S USE OF CHEMICALS

1. Think of all the different ways we use the chemicals that we call metals. Find out where some of our important metals are mined.

2. An important kind of work that makes use of chemicals is photography. Plan to visit a shop where films are developed and prints are made. Ask to be shown how chemicals are used by the photographer.

3. The fireworks industry makes use of chemicals. The elements which are used in fireworks are chosen because they give off beautiful colors when heated.

What colors would boron and sodium give fireworks?

4. Think of all the things you use that are made of plastics. Plastics are chemicals combined in new ways by man.

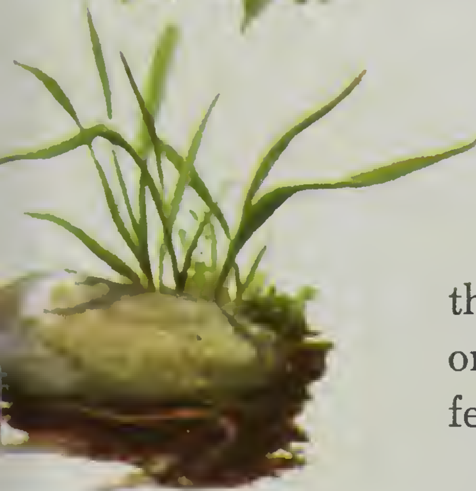
5. One of the most important chemical changes that man depends upon takes place in green leaves. In a green leaf, carbon dioxide and water combine to form sugar and oxygen. This chemical change takes place only when there is light. Sugar formed in this way is the basis of our food supply.

Why is this last sentence true?

# Animals Grow and Change


Young boll-weevil


Young salamander


Young earthworm


Young frog


Young catfish

## Animals Everywhere

Some animals we find living in trees and some in the ground. Some we find living in the sea and some on the land. There are thousands and thousands of different kinds of animals. They live all over the earth.

Even though there are many different kinds of animals, these animals are all alike in some ways. Each animal is alive. Each animal needs food to grow. Each animal grows, and changes as it grows.

Sometimes an adult animal looks very much as it did when it was young, except that it is now larger. But some young animals grow into adult animals that look very little as the young animals did.

Does it surprise you to think of beetles or worms or grasshoppers as animals? We may think of all living things as being divided into two groups. One group of living things is plants. The other group is animals.

All animals need food, but no animal can manufacture its own food. Animals depend upon green plants for food. Even though some animals feed on others, they still depend on green plants. Animals are alike in another way. They move about. Some are able to move only a little. Others move great distances.

Egg of cotton-boll weevil

Larva of cotton-boll weevil

# Boll Weevils Grow Up

Cotton country is beautiful country. Under a hot, blue sky the large, green plants bear their white or pink blossoms.

The farmer is proud of his sturdy cotton plants. Some of them reach almost to his waist or even higher. But these healthy plants will not bear much cotton if cotton-boll weevils are allowed to grow on them.

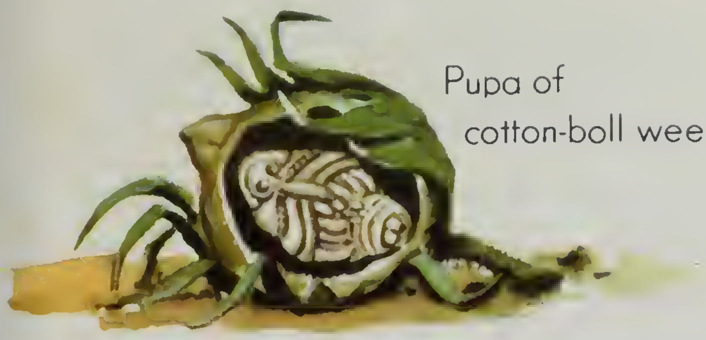
Cotton-boll weevils are beetles. They belong to the same group of animals as ladybirds, or ladybugs. Potato bugs are beetles, too. There are thousands of different kinds of beetles. Some are helpful. But some, such as the cotton-boll weevil, are very harmful.

It is known that cotton-boll weevils cause much damage. In one year they have destroyed cotton worth as much as two hundred million dollars.

Let us see how and why this beetle may be harmful to the cotton crop. The harm comes as the growing beetle feeds on the cotton flowers and cotton bolls. As it feeds, the buds and bolls are destroyed.

A female boll weevil first makes a hole in a flower bud with her long beak. Then she lays one egg in the hole in the flower bud. The egg hatches in three or four days. The grub, or larva, which crawls out of the egg looks more like a little worm than a beetle. This larva stays inside the flower bud, eating and eating.

Soon the flower bud drops to the ground because it has been injured. When this happens, no cotton will grow, because a cotton boll is the fruit of the cotton plant. And perhaps you know that the fruit of a plant develops from the flower.



Pupa of
cotton-boll weevil

Adult
cotton-boll weevil

Because the flower bud drops to the ground, there will be no cotton boll. But the larva is safe inside the fallen flower bud. It eats the bud until the resting stage in its life is reached.

The resting stage in the life of a cotton-boll weevil is called the pupa stage. Changes are taking place in the pupa, even though it is not moving about. We know this because it is not long before a full-grown cotton-boll weevil finds its way out of the fallen flower bud.

But all the damage is not yet done! The flower buds that have had no boll-weevil eggs placed in them open into blossoms. Still later the seeds begin to form. Then the petals fall, and the tiny cotton bolls grow. But sometimes before the bolls can become ripe, cotton-boll weevils attack again. This time the females lay their eggs in the bolls of the cotton plants.

Again the eggs hatch into grubs, or larvae. The larvae feed and feed on the inside of the growing cotton bolls. Then they reach the resting, or pupa, stage.

After a while full-grown boll weevils gnaw their way out as the bolls develop.

Cotton-boll weevils change within a short time from eggs to larvae to pupae to full-grown beetles. Then the females lay more eggs.

These changes take place so fast that a cotton-boll weevil may grow up and have great-grandchildren or even great-great-grandchildren in only one summer.

It is easy, then, to see why cotton-boll weevils spread rapidly over the places where cotton is grown. It is also easy to understand why they are so harmful. Just think of the thousands and thousands of cotton bolls that have been destroyed by these beetles each year!

When cotton was first grown in North America, there were no cotton-boll weevils to destroy it. These beetles are natives of Central America. But about 1890 they moved northward and began to grow in the United States too.

It is necessary to keep careful watch for these harmful beetles and to try to protect cotton plants from them. One way of protecting the plants is to plant cotton seeds that grow into new plants rapidly.

If the cotton plants grow fast enough, the cotton bolls are well started before the first cotton-boll-weevil eggs of the season are laid. For this reason much work has been done to develop fast-growing cotton.

Another way to control these beetles is to kill them. Of course they could be picked off the plants by hand and destroyed. Or each plant could be sprayed with poison by hand. But this is a long, hard job. So airplanes are used to spread poison over the cotton plants. The cotton-boll weevils can be destroyed in this way.

Ladybird beetle

Potato bug

# Potato Bugs and Ladybirds

Potato bugs and ladybirds, or ladybugs, are beetles, too. They grow and change in much the same way as cotton-boll weevils. First, eggs are laid. These eggs hatch into grubs, or larvae.

After a while there is a resting, or pupa, stage. Changes in the body of these beetles are taking place at this time. We know this is happening because pupae of the potato beetle change at this time into full-grown potato beetles. And the pupae of ladybird beetles change into full-grown ladybirds.

Potato bugs are harmful beetles. Both the larvae and the full-grown beetles eat a great deal. They feed on leaves. As you might guess, they feed on potato leaves especially. Farmers who raise potatoes have to fight this pest so that their crops will not be destroyed.

Potato plants are not native to North America. You might think that potato bugs came to North America with the potato plants.

But this is not true. Potato bugs were in North America long before potato plants. They fed on the leaves of sandburs that grew in western North America. As soon as these beetles had a chance to feed on potato plants, they did.

Now these pests have spread all over North America. To prevent them from destroying the leaves of potato plants, farmers spray their plants with poison. As the beetle eats, the poison gets into its stomach and kills it.

Not all beetles are harmful. One of the most useful ones is the ladybird, or ladybug. There are more than 150 kinds of ladybirds in North America. So far as we know, each kind is useful.

These beetles feed on small animals that destroy rose plants. They also feed on other small animals that destroy orange trees, hop vines, and cranberry plants. Ladybirds, or ladybugs, should never be destroyed.

# Grasshoppers Grow Up

Do you remember walking in a park or through a meadow on a warm summer day? Suddenly, whirr—whirr—whirr! Grasshoppers jumped as you walked along. You may have tried to catch one, but found it hard to catch.

These insects, when full grown, are able to jump several feet. Not only that, they can fly too.

When we say that grasshoppers can both jump and fly, we are really talking about the full-grown ones. Young grasshoppers can only walk or jump. They have no wings with which to fly.

Young grasshoppers are called nymphs. Here are pictures of a very young nymph and an older one. Very young grasshoppers are so small that they are hard to see.

Study these pictures of the nymphs and the full-grown grasshopper. How large the head of the younger nymph is as you compare it with the rest of its body! The head of the adult is much smaller when it is compared with the whole body. Of course the head does not grow smaller. The rest of the body just grows larger than the head.

Grasshopper eggs

Young grasshopper nymph

Older grasshopper nymph

Adult grasshopper

Black-winged grasshopper

Eastern lubber grasshopper

Red-legged grasshopper

Red-winged grasshopper

Yellow-winged grasshopper

Female grasshoppers lay their eggs in the ground. They make a hole in the ground and lay the eggs in the hole. Usually the hole is about 1 inch long. It is interesting to know that each egg is laid so that it slants upward. Because of this the nymphs can get out of the hole more easily after they are hatched.

You may be interested in seeing the eggs hatch. Perhaps you will be able to find some of the holes filled with grasshopper eggs. You must look in a meadow or in a grassy place for eggs.

Dig up the soil in which you find the eggs. Place this soil in a wide, rather flat flowerpot which has gravel in the bottom for drainage.

Plant grass seeds in the soil so that a good supply of grass will be ready for the young when the grasshopper eggs hatch. Be sure to water the grass and give it sunlight.

Take a piece of screen wire about 18 inches wide and long enough to go round the flowerpot. Stand this wire up round the top of the flowerpot. Fasten cardboard or screen wire or cheesecloth on top of the wire. Now your cage is complete.

There are many different kinds of grasshoppers. You will not know what the full-grown grasshoppers will be like when you find the eggs or nymphs. Perhaps they will be like one of those you see above.

# Butterflies and Moths Grow Up

How very, very small butterfly eggs are! The milkweed leaf above is shown in its proper size in relation to the eggs of the monarch butterfly. How small each egg is!

Usually we think of an egg as being oval like a bird's egg. But not all eggs are this shape.

One monarch-butterfly egg is shown above as you would see it under a magnifying glass. Notice that this egg is neither round nor oval. It is rather flat on one end and round on the other.

Each kind of butterfly and moth lays a different kind of egg. The eggs of the gypsy moth and the tiger-swallowtail butterfly look quite different from the egg of the Cecropia moth. And the egg of the monarch butterfly looks like none of these three eggs.

Each egg shown below has been drawn so that it looks many times larger than it really is. It is shown this way so that you can see how very different the eggs are in size and shape.



Monarch-butterfly caterpillar

Tiger-swallowtail-butterfly caterpillar

Many kinds of butterfly and moth eggs hatch a few days after they are laid. Do you know what comes out of the eggs? Yes, you're right—caterpillars.

The caterpillars of each kind of butterfly or moth look different from those of other kinds. However, in certain ways all caterpillars are alike. They all have three pairs of legs near the head. And most caterpillars have five other pairs of legs.

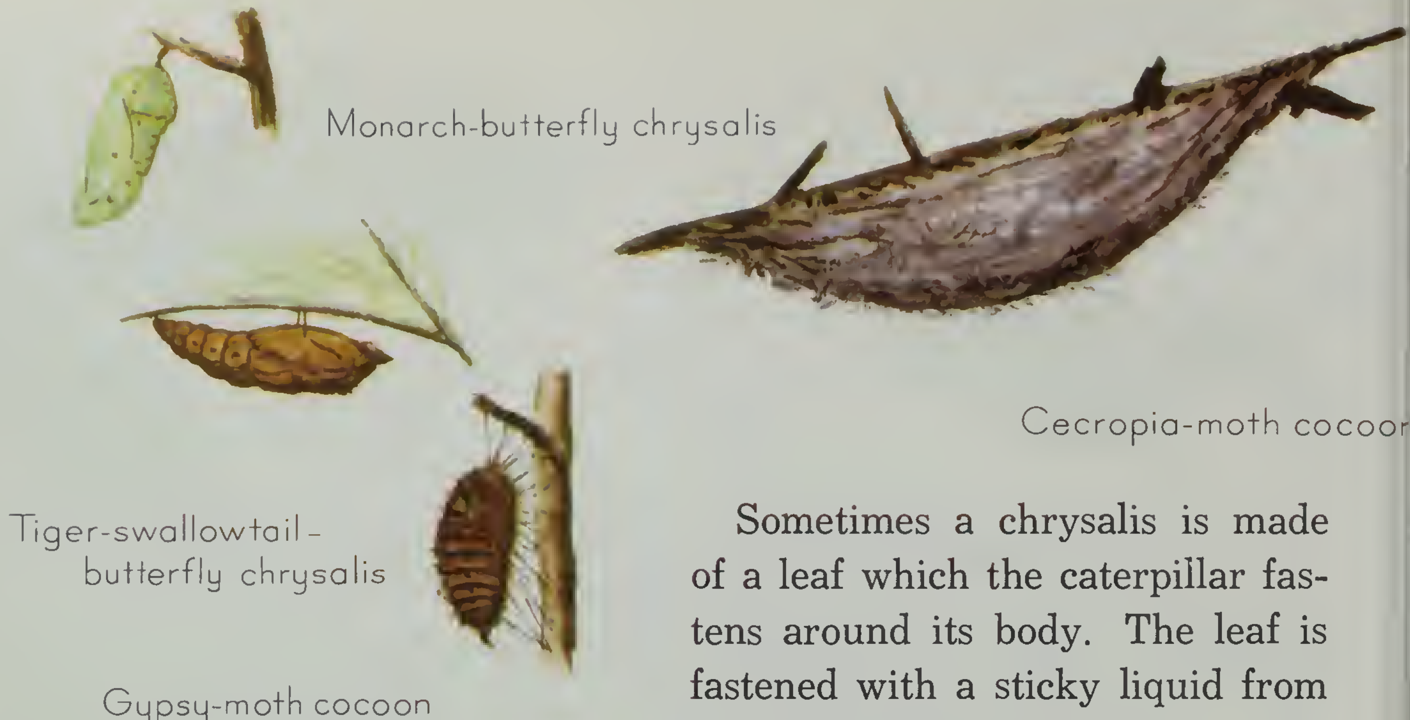
Caterpillars eat and eat and eat. Their jaws are strong and good for cutting and chewing. After a while a caterpillar becomes so fat that its skin splits down the middle of its back. Then it crawls right out of its skin.

Again the caterpillar eats and eats and eats. It grows larger and larger. Again the skin splits. Again the caterpillar crawls out, and it continues to eat and eat and eat.

A caterpillar may shed its skin four or five times during the long, warm summer. The skin is shed because each time the caterpillar has grown larger.

Gypsy-moth caterpillar

Cecropia-moth caterpillar




Later another change takes place. The caterpillar has grown to its full size. It now begins to make an outside covering. The butterfly or the moth is changing from the caterpillar, or larva, stage to the resting, or pupa, stage. This pupa covering made by many kinds of moths is called a cocoon.

The pupa covering of many kinds of butterflies is called a chrysalis. The cocoon and the chrysalis are a protection during the pupa stage.

A caterpillar makes a cocoon by spinning a long thread around itself. This thread is made of a sticky liquid that comes from an opening in the body of the caterpillar.

Sometimes a chrysalis is made of a leaf which the caterpillar fastens around its body. The leaf is fastened with a sticky liquid from the body of the caterpillar.

Each kind of moth caterpillar that spins a cocoon makes its own special kind of cocoon. Each kind of butterfly caterpillar that forms a chrysalis makes a different kind.

Certain caterpillars make neither a cocoon nor a chrysalis. They burrow into the ground and make a small hole. Here they rest.

While it is in the pupa stage, a butterfly or moth does not eat. At this time its body changes greatly.

Some butterflies are in the pupa stage only a few days. The butterfly that comes out of a chrysalis may live only until cold weather. Most moths stay in the pupa stage all winter. In the spring the moth comes out.

Have you ever seen a moth come out of its cocoon? If you would like to, take a walk through the woods or park and look for cocoons.

The best time to do this is in the autumn or winter. It is usually easier to see the cocoons then. You will find them hanging from trees or bushes. Keep a sharp watch for the cocoons, since they often look very much like dead leaves. When you do find a cocoon, do not try to pull it off. Cut the twig off the tree carefully.

Perhaps you can keep your cocoons in a screened box on the window sill outside your room. If you do, you will have to wait until spring for the moths to appear. If you keep the cocoons in a screened box inside your room, the moths will come out sooner.

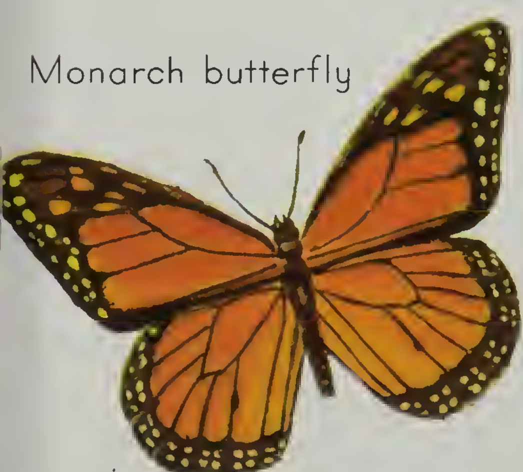
If your cocoons are kept inside, be sure to sprinkle them with water once or twice a week. Otherwise the pupae may become too dry and die.

It is a wonderful sight to watch a beautiful moth crawl slowly out of its cocoon, try its wings, and fly away.

Some moths are harmful. The caterpillars of clothes moths destroy woolen clothes. Gypsy-moth caterpillars eat the leaves of trees.

But many butterflies and moths are useful to us. They carry pollen from flower to flower. In this way seeds are helped to grow.

Tiger-swallowtail butterfly



Monarch butterfly

Cecropia moth

Gypsy moth

# Salamanders Grow Up

Curled up under a stone or a log in a moist, woodsy place, a salamander may be found. Sometimes we may find one about 4 inches long with beautiful yellow spots. This is a tiger salamander. These small animals grow and change, just as other animals do.

Female salamanders lay their eggs in water. You are most likely to find salamander eggs in a quiet pond or near the edge of a quiet brook. When you find salamander eggs, you will find not one or two or three or four, but many. These eggs are laid in a mass of greenish jelly and have no shells.

The eggs may be seen in this jelly. They look like little black dots. If you find a mass of these eggs in the spring, visit the place where you found them every day or two. In this way you will be able to watch these animals grow and change.

After a while some of the young salamanders will hatch. Then they will begin to eat their way out of the jelly. It is hard to tell just how long it will be before this happens to your salamanders. You may have found newly laid eggs. If so, it will take longer for these eggs to hatch than it would for those that have been laid some time.

Salamander eggs

Young salamander

Older salamander

Adult salamander

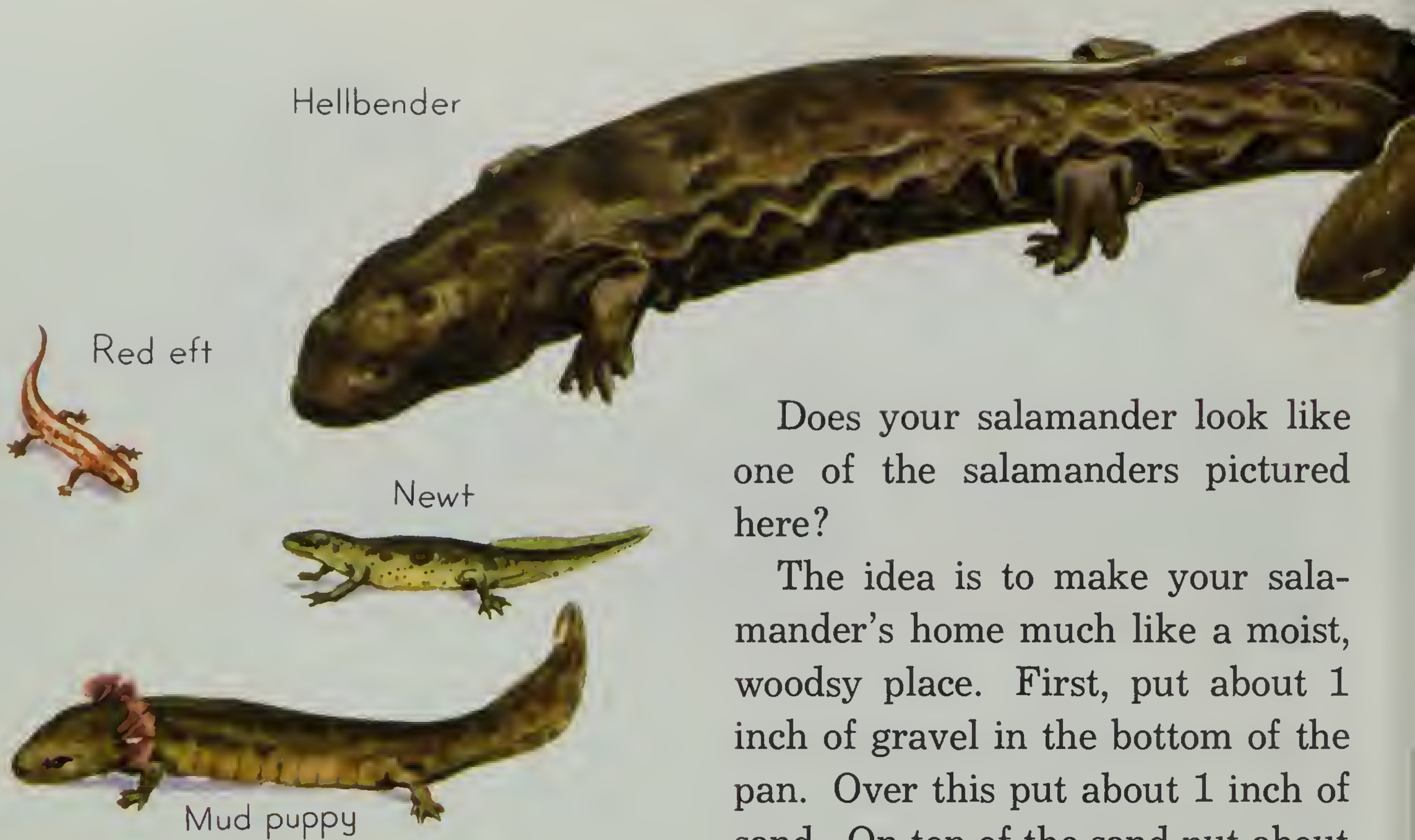
After young salamanders have hatched, they feed on the jelly. But when this is gone, they feed on small plants and animals in the water.

If you examine a young salamander carefully, you will notice its feathery gills. These gills are found just behind the head. Animals that get their air from the water do not have lungs. They have gills.

As salamanders grow and change, they develop lungs for breathing. Some salamanders have both gills and lungs. Salamanders get air through their skins also. So some salamanders have three ways of getting air during their life—by gills, by lungs, and by skin.

Perhaps you live in a place where it is not easy to get to the woods day after day. If this is true, you might like to keep a salamander in your room for a few days, where you can observe it carefully. If this is your plan, you must make a good home for the salamander.

For this home you will need a pan such as the ones your mother uses for baking rolls or biscuits. You will also need five pieces of window glass. Two of these must be cut so that they will stand up in the ends of the pan. Two more pieces will need to stand up in the sides of the pan. The fifth piece should be cut so that it will fit as a cover.




Does your salamander look like one of the salamanders pictured here?

The idea is to make your salamander's home much like a moist, woodsy place. First, put about 1 inch of gravel in the bottom of the pan. Over this put about 1 inch of sand. On top of the sand put about 2 inches of black soil, such as you find in the woods. You may want to make the surface uneven.

In the soil plant small ferns and other small plants from the woods. Moss should cover part of the soil. Here and there place a stone. Salamanders are quite shy and often hide under stones and small plants.

In one end place a shallow dish. This is to be kept filled with water. A salamander's skin is moist, and so there must be water in this home to keep the air moist. Keeping the cover on the home also helps to keep the air moist.

The two end pieces and two side pieces of glass should be put together with adhesive tape. Be sure to tape the edges of the glass around the top. The piece of glass for the top should also be taped around the edge. Now you will be able to take the cover off without cutting your fingers on the glass.

To make the sides firm, some people like to put a thin layer of plaster of Paris in the bottom of the pan. Then they stand the taped glass sides in the plaster of Paris before it hardens.

Now for salamander food. Small earthworms, small snails, bits of beef, and bits of liver may be used for food. You will be lucky if you see your salamander eat. These animals seldom eat when anyone is around.


When you grow tired of keeping the salamander, return it to the place where you found it. Salamanders and other wild animals usually live better in their natural homes than in the ones that we make for them.

On this page are pictures showing how another animal looks as it grows and changes. Toads lay their eggs in the water, and tadpoles hatch out of these eggs.

Young toad tadpoles have gills. Later they begin to develop lungs. An adult toad does not have gills. It has lungs, which it uses for breathing.

Animals that hatch from eggs laid in the water and that develop gills and lungs are called amphibians. Salamanders are amphibians. So are toads and frogs.

Amphibians, then, grow up in much the same way, whether they are salamanders or frogs or toads. Eggs are laid in the water. These hatch into young amphibians, with gills. Later, lungs develop. Then the amphibians are able to breathe air and so live on the land.

## Snakes Grow Up

Snakes are shy animals. If they see you coming, they move quickly and quietly away. They will not harm you unless you disturb or frighten them.

Have you ever happened to see a group of young snakes together in the spring? Some of these snakes may have hatched from eggs.

The eggs of snakes are fairly large and have a tough, horny covering. Look at the picture above. Do you see that the eggs of the green snake are rather long?

Female snakes lay their eggs in a warm, sunny place. If the eggs get too cold, the young snakes inside the eggs will die. When the young snakes crawl out of the shells, they look very much like their parents except that they are much smaller.

Some snakes, such as common water snakes, are born alive from the mother's body. A female water snake may have as many as thirty-five babies at one time. Think of that! Young water snakes look much like their parents, but, of course, are smaller.

Snakes too go through some changes as they grow up. They grow larger until they are full grown. They also shed their skins.

A new skin grows under the old skin. After a while the snake crawls out of its old skin. As this happens, the old skin is turned inside out, just as your socks are when you pull them off.

Snakes, then, change as they grow, but they do not go through as many changes as frogs or toads or salamanders.

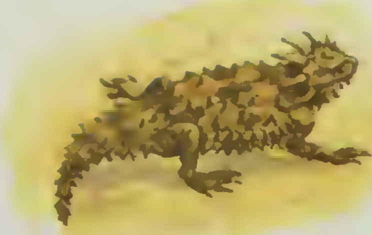
All the animals on this page are close relatives of snakes. Horned toads and Gila monsters are lizards that live in the southwestern United States. Perhaps you know other lizards, such as the five-lined lizard and the chameleon. Baby lizards look very much like their parents except that they are smaller.

Alligators and crocodiles live in warm parts of the world. They live in such places as Florida, India, and Egypt. Alligators are hatched from eggs, and they too look much like their parents.

There are ever so many different kinds of turtles. Some live mainly on the land. Others live in the sea. Some live in ponds. Some turtles are small even when they are full grown. Others, such as the giant tortoise of the Galápagos Islands, in the Pacific Ocean, may weigh as much as 500 pounds!

But no matter what the full-grown size of turtles, they all begin life in the same way. They are all hatched from eggs. Female turtles lay their eggs in a warm place on the land. The young turtles which hatch from the eggs look much like their parents.

Snakes, turtles, alligators, crocodiles, and lizards, all belong to the same group of animals. This is the reptile group. Some reptiles are born alive from the mother's body, but most of them are hatched from eggs. Reptiles change as they grow, but young reptiles look much like their parents.



Horned toad

Gila monster

Mud turtle

Alligator

# Fish Grow Up

Near your home there is probably a pond or a stream that you have visited many times. Perhaps you have even watched the animals living there.

You may have seen frogs and salamanders. You may have seen insects flying about above the water. You may have seen a snake. But surely you saw fish.

Unless one is very familiar with fish, it is often hard to tell whether a small fish is a young fish or a fish that never will grow large. Some fish, such as guppies, never grow longer than 2 inches. We know that some fish, such as the great white sharks, grow to be more than 40 feet long.

Most fresh-water fish are fairly small. A few, such as the walleyed pike, may grow to be more than 3 feet long. Sunfish and perch are much smaller.

There are small fish in the ocean too. Not only are some adult ocean fish small, but some have very queer shapes. For example, flounder and halibut are very flat.

All fish are alike in one way. They are water animals. They are born in water. They spend all their lives in water.

Fish need air in order to live, just as all other animals do. These water animals have special body openings through which they get air. These openings lead to the gills.



Fish have gill slits just behind the head. There are two of these slits, one on each side of the body. Have you ever watched a goldfish open and close its mouth as it swims through the water?

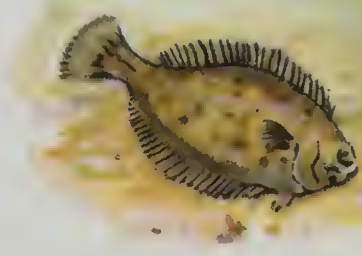
As the goldfish opens and closes its mouth, it takes in water. Fish take in water through their mouths. This water passes through a tube in their heads and out through the gill slits. Oxygen, which is in the water, passes into the blood that is in the gills.

Fish are like salamanders, frogs, and toads in one way. They are cold-blooded animals. You may know that this does not really mean that their blood is cold all the time. However, sometimes their blood is colder than ours is.

The blood of all cold-blooded animals is usually about the same temperature as the water or air in which they live. Thus, if the water becomes colder, the blood of a fish becomes colder. If the water becomes warmer, then the blood of a fish becomes warmer.

Most of the different kinds of fish lay eggs. These eggs are laid in the spring of the year. After the eggs hatch, the young fish find food for themselves.

White bass



Flounder

Catfish



Speckled trout

Yellow perch

Sunfish

Codfish

Stickleback nest

A few fish build nests and take care of their young. Bluegills build a nest which is a scooped-out place in the sand on the bottom of a pond. But the stickleback builds a nest like the one in the picture above.

Some fish—for example, guppies—are born alive from the mother's body. These fish take care of themselves as soon as they are born.

Young fish, as well as full-grown fish, eat many different kinds of food. Carp feed on vegetable matter in the soft mud at the bottom of a stream or pond. Some fish feed on fish that are smaller than themselves.

Still other fish feed on insects. The fish that eat insects are useful to us because they eat many "wrigglers," or mosquito larvae. Keeping many fish in our streams and ponds helps to kill mosquitoes.

Fish are useful to us in another way too. They are very important food. Perhaps you have eaten speckled trout that have been caught in swift mountain streams. Or you may have fished for bluegills and bass and perch in a lake near your home. These are important food fish.

Today some people who live on farms are learning more and more about the importance of fish as food. These wise people are digging ponds on their land. Then they are stocking these ponds with young fish. Farmers are raising fish, as well as pigs and chickens, to use for food.

Cod and mackerel are two of our most important ocean fish. Fishing boats go out to sea to catch these kinds of fish. They are important for other things besides food. Cod provide cod-liver oil. Fish scrap, left after the fish are cleaned, may be used as fertilizer.

If you have ever visited the Bonneville Dam on the Columbia River, you may have seen another important ocean fish. This is the salmon. Salmon are important because we use them as food. They may be eaten fresh, or they may be canned and then eaten.

Each spring many, many salmon swim up the Columbia River from the Pacific Ocean. Salmon have done this for hundreds of years. They have always had to swim against strong currents. They have had to leap over falls. But the building of an ordinary dam across the Columbia River would have prevented salmon from swimming up the river.

Salmon can leap over falls, but they can't leap over a high dam. So fish ladders had to be built at Bonneville Dam. These fish ladders are a series of man-made pools, each pool higher than the last.

Salmon leap from the river into the first pool. They swim about here for a while. Then they leap into the next pool. They leap from pool to pool until they reach the lake behind the dam.

Salmon continue on up the river to lay their eggs. The eggs are laid on the sand and gravel at the bottom of small streams flowing into the river. After the eggs are laid, most of the full-grown salmon die.

The eggs hatch into young salmon. When the young salmon reach a length of about 4 inches, they begin their long journey down the river to the ocean. Here they feed and grow larger. After a few years they are ready to swim up the river to lay their eggs and die.

Young fish do not look very different from their parents, but they may be a different color. They are certainly smaller. So they do change as they grow up.

Young Pacific salmon

Adult Pacific salmon

# Birds Grow Up


Robin

Have you ever watched young robins grow up? How busy they keep their father and mother! The full-grown birds hunt for food from dawn until evening. The wide-open mouths of the young robins must be stuffed with food many times each day.

But the busy life of the parent robins starts before the young appear. First, a nest has to be built. A robin's nest is often built in a tree. The outside of the nest is made of sticks and mud. The inside is lined with soft string or leaves or bits of paper. The nest is protected from rain by the leaves growing over it.


Red-eyed vireo

Many birds other than robins are busily building nests in the spring and early summer. Red-eyed vireos build nests like baskets. The wind makes these nests move from side to side. Each nest is put together so strongly that the wind does not blow it apart.

Woodpeckers build their nests in trees, but you cannot find these nests easily. They are built inside a tree trunk. This makes a safe, snug place for the young birds.




Barred Plymouth Rock

Not all birds build their nests in trees. Quail and pheasants make their nests on the ground. These nests are very well hidden in the grass. Sometimes these birds build their nests in wheat fields. As the farmer is harvesting his grain, he sometimes sees birds fly up out of the grass. Then he will run his machine carefully around this place so that he will not harm the nest.

If there is a stream near your home or school, and it has high banks, look along the banks for birds' nests. Some birds, such as bank swallows, build their nests in holes in the bank of a stream.

If possible, look in a barn for the nests of barn swallows. Look here also for the nests of chickens. Don't forget that chickens, ducks, geese, and turkeys are birds. Perhaps you will find the nests of pigeons in a barn, too.

You will never find the nests of some birds, however, because they build no nests. Cowbirds never build nests. They do not need them, since they lay their eggs in the nests of other birds.

Barn swallow

Hummingbird

Quail

Cedar waxwing and young

Almost all birds build nests, but they do not all build the same kinds of nests. Different kinds of birds build different kinds of nests.

However, birds that are alike build almost the same kind of nest. In other words, robins build nests that look alike, although some robins' nests may be smaller than others. Vireos build nests that look alike. So do quail and hummingbirds and barn swallows.

Just as different kinds of birds build different kinds of nests, so do different kinds of birds lay eggs of different sizes and colors. A chicken's egg looks quite different from a robin's egg. The chicken's egg is brown or white. The robin's egg is blue.

Cedar-waxwing egg

Though the eggs of birds are of many different sizes and colors, they are all somewhat alike inside. You know what a chicken's egg is like inside. It has a white and a yolk.

The young chicken begins its life as a very, very small part of the yolk. In fact, it is so small that you would be able to see it only with a microscope.

Hummingbird egg

The yolk of a bird's egg is chiefly stored food for the young bird. Its body will absorb this food while it is still in the egg.



Chicken egg

White Leghorn and young

All birds lay eggs. No bird is ever born alive from the mother's body in the way that some snakes and fish are born alive.

Most female birds are very busy mothers. They do not leave their eggs to be warmed by the sun to hatch, as turtles do. Mother birds keep their eggs warm with their own bodies. Sometimes father birds keep the eggs warm while the mother birds hunt for food.

Different kinds of birds must keep their eggs warm for different lengths of time before they will hatch. It takes twenty-one days for chickens to hatch. Goose eggs must be kept warm about twenty-eight days. Robins' eggs hatch in about fourteen days.

Some young birds can hunt for food in a few days after they are hatched. Young chickens, ducks, turkeys, and quail are able to follow their mothers around after a few days. But they do not really hunt for food themselves. They follow their mothers and wait for them to find the food. Have you ever watched hens hunting food for baby chicks?

Young wrens and robins and owls, as well as many other birds, stay in the nest and wait for food to be brought to them.


Oriole and young


Oriole egg


Goose egg


Quail egg

Quail and young


# Birds Are Alike in Many Ways

Young birds do grow and change. But it would not be hard to tell which young animals are birds. One reason is that all young, as well as full-grown, birds have feathers.

Chickens, ducks, and quail have many soft, downy feathers when they are hatched. Some young birds, such as young robins, have almost no feathers. They cannot fly until their feathers grow.

All birds have beaks, but no teeth. Some beaks are short and thick and good for cracking seeds, and others are very good for tearing food.

The feet of birds are somewhat alike, too. Perhaps you have noticed the feet of chickens. Perhaps you have seen chicken tracks in the dust of a chicken yard. Did you notice the three long toes and the one short toe in the tracks?

You may have noticed the tracks of sparrows or chickadees in the snow, or of sandpipers and other shore birds in the wet sand. Did you see the three long toes and the one short toe in the tracks?

The feet of some birds are so strong that they can be used for walking and scratching. Each toe has a strong nail, or claw, that is used for scratching.

Some birds have feet that can hold on to things tightly. The toes are strong and can curl around the branch of a tree. A bird with such feet can hold on to a branch even while asleep. Robins, hawks, and owls have such feet as these.

Some birds have skin between their toes. These are the webfooted birds—for example, the ducks. Webbed feet are good for swimming.

It might be interesting to make a classroom exhibit that would show how birds change as they grow.

Perhaps, as a starting point, you could collect feathers. In a chicken yard you could find the feather of a young chicken and a much larger feather of its mother or father. Feathers may also be found on the ground under trees or bushes where birds make their nests.

You may wish to make accurate drawings to show the change in size of the feet of birds. Measure the length of the toes in tracks made by baby chicks. Then, in the same way, measure the length of the toes of hens or roosters.

Make your drawings of the chicken tracks the same size as the real tracks. What small feet young chickens have in comparison with their parents! But notice how very much alike these tracks are.

You might also make accurate drawings of turkey tracks or duck tracks. It probably would be very hard to find the tracks of both young and full-grown sparrows.

Some people have made fine collections of the homes of young birds. There is one very important thing to remember, though, if you wish to make such a collection. The nests must never be taken except in the late fall or during the winter. At this time of year the birds are no longer using their nests.

Here is one more suggestion to help you to understand better how birds grow and change: First, find out if someone in your neighborhood raises pigeons, ducks, chickens, or turkeys. When the young birds are hatched, visit them. Make an accurate record of their size and color. Do this every three or four days until they are full grown.



# Guinea Pigs Grow Up

Do you have a pet? Wasn't it fun to watch your puppy grow up? Perhaps you have a kitten that is growing up day by day. Or you may have a pet bird.

Pets such as these are fun to have and fun to take care of. In the picture below is another kind of pet that some children like very much. These are guinea pigs.

Guinea pigs are not really pigs. They belong to the same family of animals as do rabbits, squirrels, mice, rats, and beavers.

No one has ever found wild guinea pigs in North America, but wild guinea pigs are found in South America. The kind that people keep as pets are domesticated, just as sheep, horses, cows, and dogs are domesticated animals.

Female guinea pigs do not lay eggs. The young are born alive from the mother's body. Young guinea pigs are much smaller than their parents, but they look very much like them.

These young animals are covered with hair, or fur. They are soft and cuddly. Their noses, which move up and down, seem to be snuffling for food. The young guinea pigs make noises which sound very much like the chirping of birds.

At first young guinea pigs feed on milk from the mother's body. But soon the young animals begin to eat the same kind of food that the full-grown animals eat.

If you have guinea pigs for pets, you will want to see that they have a good diet. They eat such grains as oats, corn, and wheat. Guinea pigs also like lettuce, carrots, and fresh green grass.

Be sure that the food for your guinea pigs is fresh and clean. You will also want to see that they have water. They will not drink much water, since they get it from fresh, green vegetables.

Sometimes young guinea pigs look different from their mothers because of their color. A brown female guinea pig may have some brown and some white babies. This is because the father or one of the grandmothers or grandfathers had some white fur.

Some guinea pigs have black in their fur. Even so, guinea pigs look very much like their parents.

If you wish to keep these animals as pets, you must build a cage or pen for them. Look at the picture below to get ideas for building your pen.

First, you will need to build a frame of wood. The frame should be about 18 inches high and about 4 feet long and 3 feet wide.

You will need to nail wire-mesh screening around the sides. If you wish, you may also make a wire bottom and top for your pen, but this is not necessary. No top is needed, because guinea pigs do not jump or climb. If there is no bottom, you will find the pen easier to clean.

The pen should be placed on several layers of newspaper. This newspaper should be changed every day. You may want to put a wooden box in the pen so that the guinea pigs can sleep in it.

Make a hole in one side of the box for the door. Place the box in the pen with the open side down.

Guinea pigs should be kept in a place with a temperature of about 72 degrees. Watching guinea pigs grow is fun!

# Other Young Mammals

All the young animals shown on these two pages are alike in one way. Every one of these animals is a mammal. A young mammal is an animal that feeds on milk from the mother's body.

Young guinea pigs, cats, mice, dogs, rabbits, horses, cows, pigs, wolves, foxes, bears, deer, whales, elephants, bats, squirrels, and many, many other young animals feed on the mother's milk.

Every one of these animals belongs to the same group. This group of animals is the mammal group.

There is another important difference between mammals and all other animals. Mammals have hair on their bodies. Horses, cows, and seals have hair on their bodies.

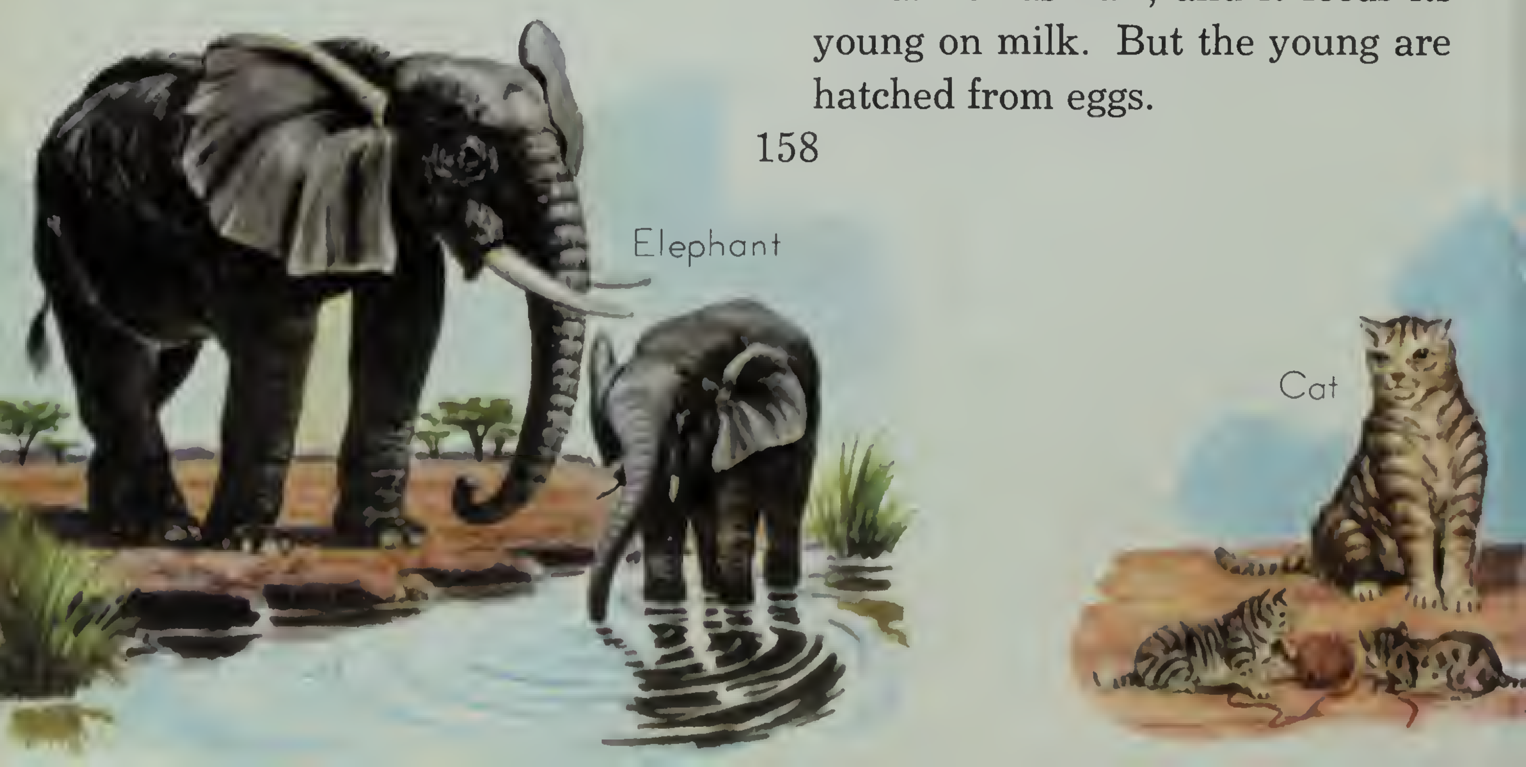
Sheep have much thicker hair. We call their hair wool. Seals, muskrats, minks, beavers, and leopards are killed sometimes because they have such beautiful coats of hair. We call this hair fur and use it for coats, muffs, and scarves.

Now let us think about young mammals. Many of them, such as kittens, puppies, and mice, are helpless when they are first born. Their mothers keep their young warm, feed them, and protect them from danger.

Most mammals bear their young alive. That is, they do not lay eggs. This is not true of two mammals.

The duckbill, shown on the next page, is an egg-laying mammal. This queer animal lives in Australia. It has hair, and it feeds its young on milk. But the young are hatched from eggs.





The other egg-laying mammal is the spiny anteater. It lives in Australia, too.

Even these mammals that lay eggs take good care of their young. They keep them warm. They protect them from enemies. They feed them milk from their bodies, just as other mammals do.

Certain mammals—for example, the opossum and the kangaroo—carry their young around with them for a while after they are born. The mother opossum carries her young around with her for about eight weeks after they are born. First, they are carried in a pouch and then on her back.

Sometimes the mother opossum has a second group of babies before the first ones are ready to leave her. When this happens, the older babies are carried on her back. The tiny, younger opossums are carried in a pouch.

Young kangaroos weigh about an ounce when they are born. They climb into the mother's pouch and stay there until they are larger.

Even after a young kangaroo is able to move about easily, the mother takes good care of it. If there is danger, the young animal jumps back into its mother's pouch, and the mother jumps away with her strong legs.

Some young mammals have little or no hair when they are first born. This is true of mice, rats, opossums, and kangaroos.

But after a little while all young mammals look a great deal like their parents. They are not as large, of course.

Mammals change as they grow up. Think of all the ways they change as they grow.




## DISCUSS THESE THINGS

1. Have you ever had a good discussion with your group about whether or not you should keep animals in your classroom?

Do you think it is necessary to have an aquarium if there is a stream or pond near your school that you can visit? Why do you feel the way you do about your answer to this question?

What are some things you will need to think of before you bring any animals into the classroom?

2. Have you ever heard anyone say that toads cause warts? Do you think this is true? Men and women have really studied this question. It is not true. Toads do give off a bitter-tasting liquid, but it does not cause warts.

## YOU MIGHT LIKE TO TRY THESE

1. If your group thinks it is wise to have an aquarium, here are some hints on how to make one:

First, you will need a tank or container of some kind. If you have a regular aquarium tank, use that. If not, you can use a large, plastic refrigerator dish.

Or, for only one or two small fish, you might use a large, wide-mouthed olive or pickle jar. First, wash the container with a brush and warm water. Do not use soap or cleaning powder, because they are hard to wash off.

You need enough sand to cover the bottom of your tank to a depth of about $1\frac{1}{2}$ inches.

This sand should be washed several times to make sure it is clean before putting it in the tank. You may get plants that grow in water from a stream or a pet store. Set the roots firmly in the sand.

Add the water. First, lay a piece of clean wrapping paper over the sand and plants. Pour water onto this paper so that the sand will not be disturbed. Fill the tank to within 1 inch of the top. Then remove the wrapping paper.

Let the water stand overnight before putting in the fish and snails. Now the water will be at room temperature, and it will be clear because the sand will have settled.

Do not put too many fish in your aquarium. About 1 inch of fish to 1 gallon of water is a good rule to follow. Do not count the tail in this measurement. If you have two fish each 2 inches long, you will need 4 gallons of water. A glass cover should be kept on the aquarium to keep out dust and dirt.

2. If you like to watch birds, make a feeding station. Fasten a flat wooden shelf outside your window.

The shelf should be as long as the width of the window and about 2 feet wide. A glass cover about 6 inches above the shelf is good to keep rain off the birds' food. Put grain and sunflower seeds on the feeding station each day.

3. Find out which snakes in your part of the country are poisonous. You might get this information by writing to the Department of Zoology at a nearby university.

If there is a zoo with a reptile house near you, visit it so that you will know the poisonous snakes. If you cannot do this, learn to recognize them from pictures.

4. Find out if there is a chicken or turkey or duck farm near you. Arrange to visit this farm. Ask the owner to show you the incubator and the brooder. Perhaps you will be able to see some of the young birds. Try to find out what one must know to be successful in raising these birds.

# About Balance and Shape

## Balancing Things

What fun it is to go to a circus! So many things are happening at one time that it is hard to watch all of them. The band is playing. Clowns keep us laughing. Acrobats perform wonderful stunts. Trained animals are at work in the big rings.

Think of tight-wire walkers. These people walk and run on a thin wire stretched high in the air. They are well balanced as they move quickly back and forth across the wire.

The elephant is able to stand on the narrow box because he is well balanced. The clown balances a long stick on his nose.

If the tight-wire walker leans too far to one side, he will fall. If the elephant leans too far forward, he will fall. The clown will lose his stick if he leans too far forward. Let's think about balance and what it is.

1

2

3

Have you ever watched a little boy or girl playing with blocks? You probably played with blocks once yourself, but have forgotten about it. If you can borrow some blocks, you may discover some interesting things about balance.

If you have some blocks or pieces of wood, try to build them in the ways shown on this page. Which of the block towers are so poorly balanced that they will fall over?

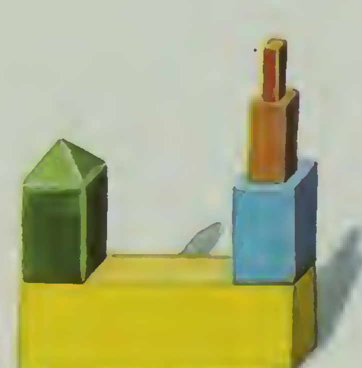
Did you say that number 2 and number 6 would fall over? You're right. Unless you build numbers 3, 4, and 5 very carefully, they will fall over, too. Number 1 is very steady. It is easy to build. It will not fall over easily, because it is well balanced. The first block towers that little children build often look something like number 1.

Number 2 will fall over easily. It is not well balanced. There is too much weight on the left side. Number 3 can be well balanced so that it will not fall over. To do this, the exact center of the top board must be placed on the middle block. In this way the weight of the top board is equal on both sides.

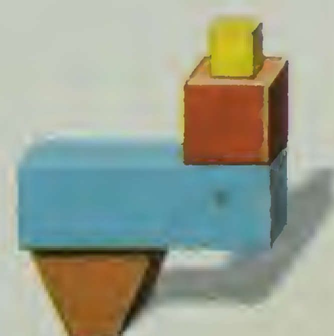
Number 4 is hard to build, too. Unless each of the blocks is placed exactly in the center, the three top blocks will fall over. This is also true of the towers on number 5.



4



5



6

If you build very carefully, you may be able to build part of number 6. The first block will stand up. You may even be able to put the second block in place.

But do you think you could ever put the two top blocks in place? No, all four blocks would fall over right away. They would not balance. The blocks in numbers 2 and 6 are quite out of balance.

Acrobats must learn the secret of balance, too. The men shown here are well balanced. The top man placed his feet on the shoulders of the bottom man so that his weight is balanced.

The two men on each side weigh about the same. They pull with an equal amount of force in opposite directions. These two acrobats on each side must be very careful to take their positions at the same time. If one should try to take his position before the other, the center man would be pulled off balance.

Notice that the feet of the center man are wide apart. He would have a very hard time balancing the other men if his feet were close together. It is hard to balance something wide on a small base.

So the center man holds his feet wide apart. His feet then make a wide base for easier balancing.

Have you ever watched a trained dog or some other animal standing or walking on a large ball? This is a very hard thing to do. What do you suppose would happen if the dog leaned too far forward? What would happen if he leaned too far backward?

Trained dogs can stay on top of a ball as it rolls along the floor. But they must learn to move their feet very quickly.

They must also hold their feet close together. The most important thing that they must do is to keep as much weight on one side as on the other. A dog trained in this way has learned to balance.

# Holding Things on the Earth

Have you ever wondered why you do not fly off the earth into space? Birds fly in the air and airplanes travel there, too. But neither really leave the earth.

Birds, balloons, and airplanes move about in the air, but they have not left the earth, because the air is a part of the earth. It is just as much a part of the earth as are water, soil, and rocks.

These and other things are not able to leave the earth because of gravity. The earth's gravity is great enough to keep things on the earth.

Gravity is always pulling things toward the center of the earth. Hold your pencil about 2 inches above your desk and then let it go. Of course it falls.

Hold a piece of paper in the air and let it go. It may float for a little while, but soon it falls to the floor. Throw a ball up in the air. Down it comes, too.

Jump up in the air. You can't stay up unless there is something to hold you up. The earth's gravity pulls you down, just as it did the pencil, the paper, and the ball.

Perhaps you are wondering just what gravity looks like or what it feels like. No one could answer that question, because no one has ever seen gravity.

The earth's gravity pulls on things. It acts something like magnetism. Magnets pull toward them things that are made of iron or steel.

The earth's gravity is different from magnetism because it pulls on everything. It pulls on things made of iron or steel. But it also pulls on water, air, cloth, people, stones—everything!

We often measure the pull of the earth's gravity on our bodies. We do this every time we step on the scales. Our weight is the number of pounds of force with which the earth pulls on us.

If you weigh 100 pounds, then the earth is pulling on you with 100 pounds of force. If you weigh 85 pounds, then the earth is pulling on you with 85 pounds of force.

Sometimes people think that the size of a thing is the only thing that causes it to weigh a certain amount. But this is not true.

You cannot always tell about the weight of a thing from its size or shape. Look at the three balls below. Which ball weighs the most? Which weighs the least? Or you could say, "On which ball is the earth pulling most strongly, and on which ball is the earth pulling least strongly?"

You cannot answer these questions by just looking at the picture. The balls are all the same size. So what else would you need to know about them?


Yes, you would need to know what they are made of. Ball number 1 is cork, number 2 is steel, and number 3 is pine.

Now you will say ball 2 is heaviest and ball 1 is lightest. And you will be right. The steel ball is made of heavy particles which are packed tightly together. There is very little space between them.

The cork ball is made of the lightest particles, and these are not packed very tightly together. There is much air space in the cork ball.

Here is another interesting thing about the earth's gravity: it pulls everything toward the earth at the same speed if nothing gets in the way of the thing being pulled.

Study the picture at the top of this page. The boy and girl have each dropped wooden balls weighing exactly the same amount.


They have also dropped pieces of tissue paper weighing exactly the same amount. The ball dropped by the girl is falling faster than the tissue paper. But the boy's tissue paper and ball are dropping at the same speed.

Notice that the girl's ball and paper are falling freely in the air. The ball and paper dropped by the boy are falling in a glass tube.

Have you guessed the secret? Yes, the air has been removed from the glass tube. When there is no air to get in the way of things that are falling, they will fall at the same speed. It makes no difference how light or heavy they may be.

If things are heavy enough, they will fall at the same speed, even though they are falling through air. To show this, get two heavy stones of different sizes. Drop them at the same time from the same height. They will hit the ground together.

We have been thinking about the earth's gravity. We could talk about the gravity of anything on the earth, since everything on the earth has gravity.

But things on the earth, such as people, are so much smaller than the earth that their gravity is not noticed. For instance, we do not notice that two balls pull on each other. However, the pull of each ball on the other can be measured.

Not only do things on the earth have this force called gravity, but so do the moon and other sky bodies. The moon is smaller than the earth, and so it has less gravity. If you weigh 100 pounds on the earth, the moon would pull on you with a force of only about 16 pounds.

On Jupiter you would weigh about 264 pounds. Of course your body would be no larger. But since Jupiter would pull on you more, you would weigh more.

# A Force Which Opposes Gravity

Look at the picture below. It shows what would happen if it were not for the earth's gravity. Everything on the earth would move off into space.

Even the earth itself would go to pieces. The air would disappear; the water would flow out of the lakes and oceans; the soil and stones would move swiftly out into space. Soon there would be no earth at all.

Have you wondered why gravity does not pull everything all the way to the center of the earth? This is partly because of another force, called centrifugal force. No one can see centrifugal force, but we can see what it does.

Things on the earth have centrifugal force because the earth is moving round and round on its axis. The earth turns completely round once during each twenty-four hours.

Anything that is moving round and round will move away in a straight line if it can. You are moving round and round because you are on the earth. Every single minute your body tries to move off the earth. But it can't because of gravity. The earth's gravity keeps pulling your body back to the earth.

The earth's gravity and centrifugal force oppose each other. Just think of what might happen if gravity were not at work!



# Problems of Builders

The men who plan buildings must think about gravity and balance. The shape of a building must be such that gravity does not pull too much on one side or another. A building must be balanced.

Shapes of buildings tell you something about the way they are balanced. If any part of a building is narrow, that part is usually at the top.

This is true of many skyscrapers. The tops of these tall buildings are often very narrow compared with the lower parts.

Study the picture above carefully. Notice the shapes of the buildings. Notice the towers and the dome. Notice the shapes of the smokestacks.

Many of the large apartment houses in the city in the picture look almost square. Their walls go straight up. There are no tall, narrow towers on the tops of these buildings. They are very sturdy.

Even the tall chimneys on the factories are built so that they are well balanced. They are broader at the base than they are at the top.

From a distance a tall chimney may appear as though its sides went straight up from the base. But if you look closely, you may see that the chimney becomes narrower as it gets taller. Tall chimneys are better balanced when they are built in this way. Builders really balance buildings much as children balance blocks.

Bridges have to be built so that they are well balanced. Some of our bridges, like this one, are arched. Have you ever noticed one of these arched bridges? There may be one near your home.

Engineers who build bridges must work out the design very carefully. They must know the weight of the bridge and the load it will carry. They must also know how long the bridge is to be. After they have these facts, they are ready to design the bridge.

In building a bridge with arches, one of the most important things for the builder to do is to make the arches just broad enough. If the arches are too broad, there will not be enough support for the top of each arch. The bridge may break through with a heavy load.

Each of the pillars of the arch must be wide and strong. These pillars support a great deal of weight. They support the roadbed of the bridge and the trains or automobiles that use the bridge.

Engineers also build bridges that have other shapes. In some places it is not wise to build an arched bridge over a river.

Sometimes large boats go up the river. The boats may be too large to go through archways. In such places are built suspension bridges. These bridges are often made almost entirely of steel.

A suspension bridge is shown below. This bridge crosses the Detroit River between Detroit, Michigan, and Windsor, Ontario. The whole bridge is more than a mile long. It is called the Ambassador Bridge. The roadbed between the tall steel towers is held up by very strong steel cables.

The Ambassador Bridge was carefully designed so that the roadbed and its load would not be too heavy for its cables. Engineers thought of gravity when they planned this bridge.

People all over the world have been building houses, temples, and other kinds of shelters for a great many years. Many of the ancient structures are so well built that they are still standing today.

Above is a picture of three very famous old structures which are near the mouth of the Nile River in Egypt. These structures are about five thousand years old. We call them the Pyramids.

The Pyramids were built by some of the kings of Egypt. They are the tombs of these kings.

Notice how well balanced these buildings are. They are broad at the base and gradually become more and more narrow at the top. These are sturdy buildings. They have lasted a long, long time.

At the bottom of this page is another very old building. Did you guess that it is Chinese? This interesting Chinese temple was built hundreds of years ago.

This is not a very large building, as you can see from the people walking up the steps. At first glance you would say that the Chinese temple looks quite different from the Pyramids.

But look at the two pictures again. Notice the design of each of these buildings. Each has the same general design as many of the buildings that you know very well in your town.

The temple and the Pyramids have wide, strong bases. Each of these buildings becomes more and more narrow at the top. But each building is carefully balanced on its wide, strong base.

It might be interesting to make a collection of pictures of famous old churches which have been built in different parts of the world. Try to find a picture of the great cathedral at Reims in France. It took many, many years to build this church. It is so well built that it is still standing, though it was finished about six hundred years ago.

Find pictures of old churches in Germany and England and Italy. Find pictures of Russian churches. There are some very interesting old churches in Quebec, Nova Scotia, Florida, and Mexico. There are also interesting ones in New England and Alaska.

As you study these buildings, you will find that each of them was built with a broad, sturdy base. The towers and steeples are balanced on these bases.

At the top of this page is a picture of one of the oldest and most interesting houses in Canada. Perhaps you have visited this house.

This is the Château de Ramezay. It is now a historical museum and art gallery in Montreal, but it was once the home of governors of British North America.

Claude de Ramezay, an early governor of Montreal, had this house built as his home more than two hundred and fifty years ago.

It was built to last for many, many years. It is built so that it is strong and steady. It is well balanced.

Below is a modern house. It looks quite different from the Château de Ramezay. Houses may look different, but their basic design may be the same. Houses must be built to be well balanced, strong, and sturdy.

Churches, business buildings, and homes may have different styles. But they have wide, steady bases for balance.

# Through Air More Easily

You know that air is a real thing. It presses on us. As we walk, we push through the air.

Air is strong enough to hold things back. Automobiles and trains must move through the air. They push the air aside as they move.

This experiment will help you to see how air holds things back as they move through it: Place a piece of paper flat against your hand. Now throw it with as much force as you can.

Did it go very far? Make a light chalk mark on the floor where the paper fell.

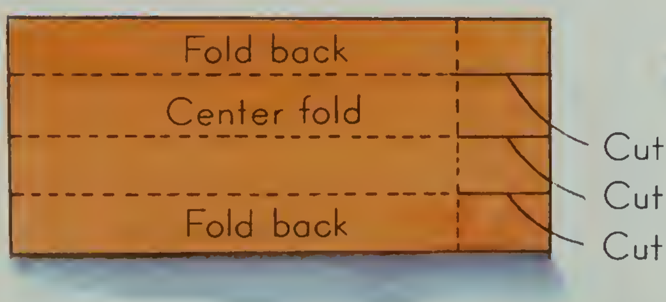
Take the same piece of paper. Crumple it into a tight ball. Stand where you were standing before. Now throw the paper as hard as you can. Did it go farther this time?

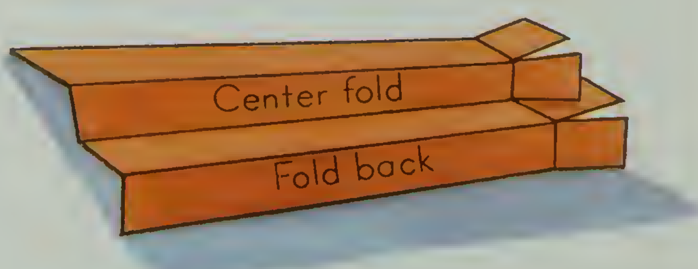
Try to explain why you could throw the crumpled paper farther than the flat paper. Certainly the crumpled paper was not lighter.

You used the same paper each time, and so the weight was the same. You may not have used exactly the same amount of force each time. However, each time you threw as hard as you could. So the force was about the same.

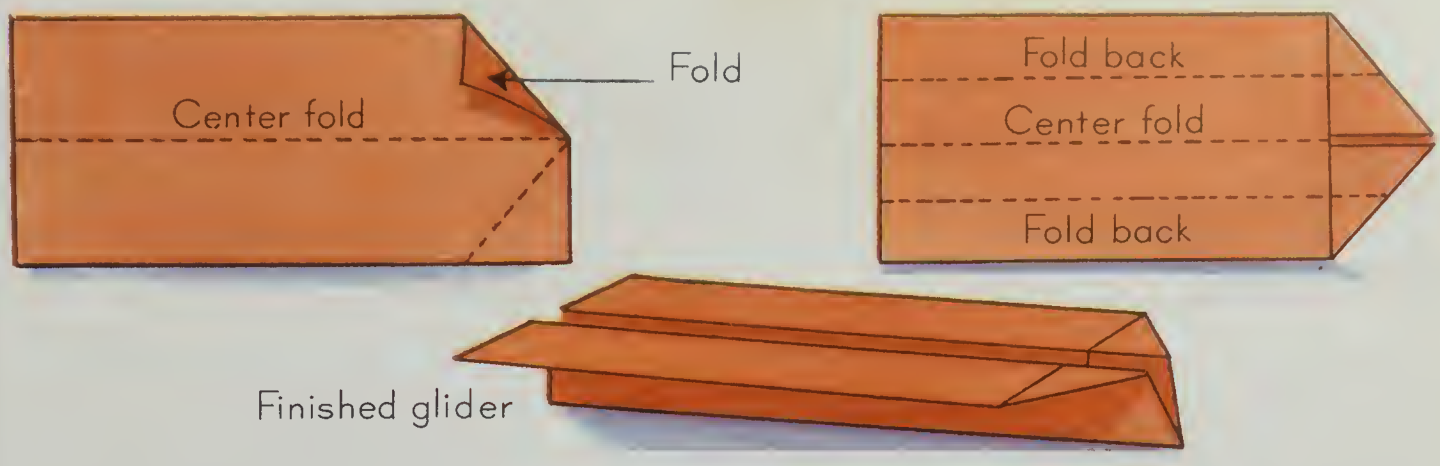
But you did change the shape of the paper. The flat piece of paper took up more room. So it had to push against more air as it traveled.

When the paper was crumpled, it did not have to push against as much air. It could travel faster, though you used about the same amount of force both times you threw the paper.




Finished glider




Now let's experiment by making and using paper gliders.

You will need two pieces of paper, each about 8 inches wide by 12 inches long. Draw on one paper the lines you see in the first picture on the opposite page. Cut along the heavy lines.

Fold the paper along the center dotted line. Then fold back on the two outer dotted lines. Look at the second picture on the opposite page to be sure you understand.

Now look at the third picture on the opposite page. Fold the cut ends so that they make a flat nose for the glider. Doesn't it look queer?

Throw the glider as hard as you can. Does it go very far?

Now you are ready to make the second glider. You have probably often made gliders like this one. Keep the first glider to compare with the second.

On the second piece of paper draw the lines that are shown in the first picture above. Fold back each corner as is shown.

Now look at the second picture above. Draw the lines shown. Fold the paper along the center and back at the outer edges.

Does your second glider look like the third picture above? This second glider is no heavier than the first, but it looks quite different.

Throw this second glider as hard as you can. It travels much farther than the first with about the same amount of force.

The secret of this glider's longer flight is its shape. The pointed nose did not have to press against as much air as the square-nosed glider. It is more streamlined.

We streamline the shapes of automobiles and trains so that they can go through the air more easily.

## Shapes of Automobiles and Trains

The automobile at the left above is not very old, although it does look different from more modern automobiles. It is the kind of automobile your parents' older brothers and sisters may have taken rides in when they were just about your age.

Compare the two automobiles above. What are some of the differences? The engine cover, or hood, of the older one is more nearly square. The front of the radiator is not very pointed. Notice the flatness of the top. Notice how the headlights stick out in front.

The lines of the automobile of today are smoother. It seems to be all in one piece. Very few things extend beyond the main body. Automobiles of today move through the air more easily because they are streamlined.

Suppose you could go back and visit a child in the year 1918. It is summer, and you are going on a vacation. You will not drive. This is to be a train trip.

This trip will be a very exciting one. You will ride on one of the fastest trains in the country. It will go 60 miles an hour. This train will look like the one on the left below.


Now look at the second train on the opposite page. This is a train on which you could take a trip today. Sometimes this train travels as fast as 90 miles an hour!

Notice the differences in the shapes of the two trains. The older locomotive has a headlight, wheels, and other parts extending beyond its main body. These things seem to be stuck on to the locomotive.

The same is true of changes in trains as of changes in automobiles. Locomotives and automobiles now look as though they were made in one piece.

Why do you suppose designers made these changes? Probably one reason was that the shapes are now more beautiful. But the other reason was that these smooth shapes move through air more easily.

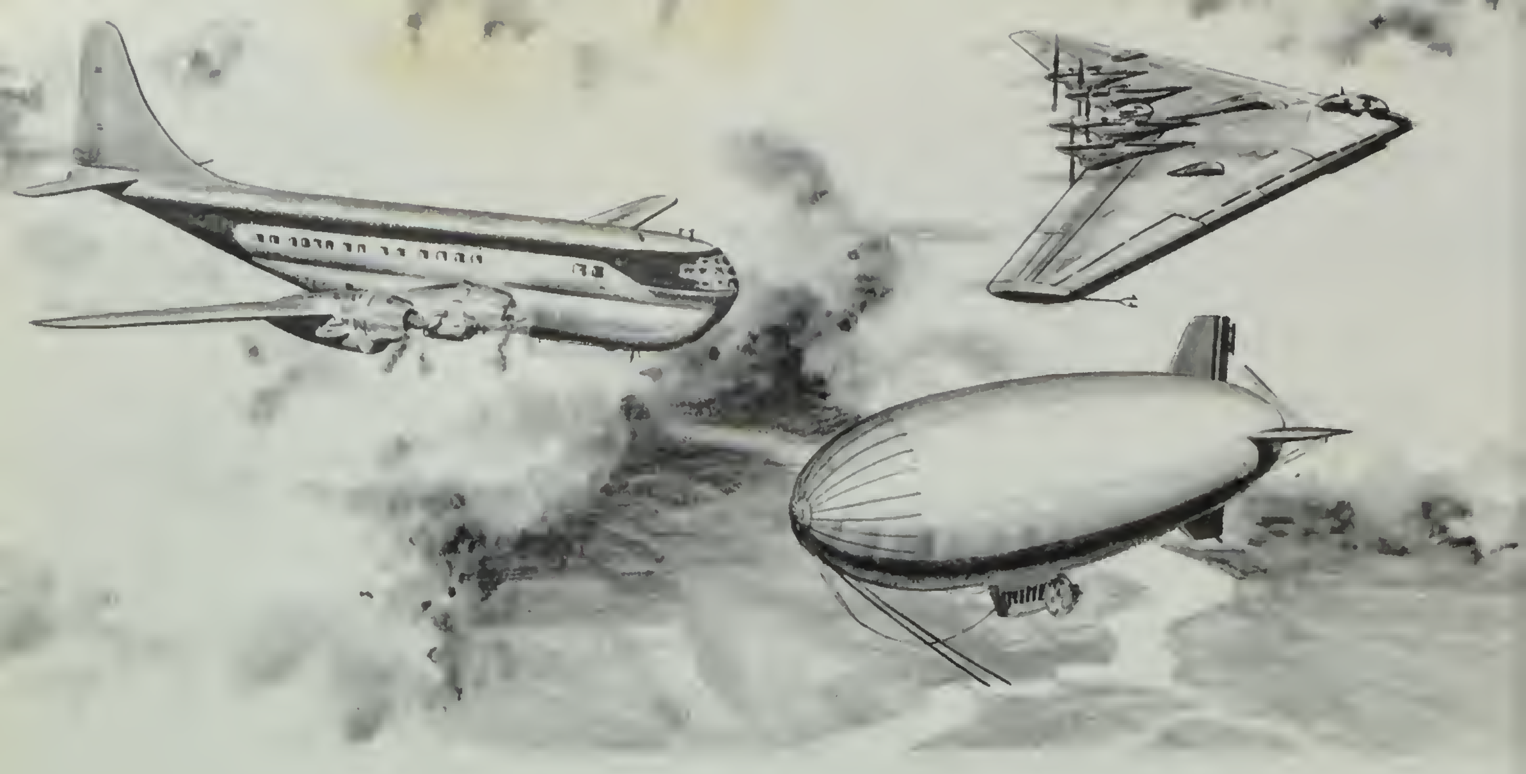
## Shapes of Ships

Now let us think about the shapes of ships. Let's think especially about the part of a ship that must move through the water as it travels along.

Study the ships above. The shape of a submarine is very much like the shape of a fish. Submarines are as smooth and straight as they can be. Only a small part of this ship is raised.

The top of an ocean liner is not as smooth as the bottom. Why must the part of the liner that is under water be smooth?

Since the top of an ocean liner moves through air, it must be as smooth as possible. Modern designers streamline the whole ship. Ships are designed in this way so they can move more easily through water and air.



## Shapes of Aircraft

It is exciting to watch birds as they soar high overhead. Have you watched hawks or eagles as they move through the air? Or perhaps you have watched gulls zooming down to the water below.

Only once in a while do the wings of these birds move. The birds seem to float in the air.

Hawks and eagles and gulls are very beautiful. Their bodies seem to be streamlined. When they fly, these birds pull their feet up close to their bodies. Their heads are in a straight line with the rest of their bodies. In this way the bird can cut through the air easily.

Look at the passenger plane on the left above. Does the shape of this aircraft remind you of a soaring bird? We have shaped our airplanes in much the same way as a bird's body is shaped.

Notice the still smoother shape of the flying wing above. This new type of aircraft should be able to cut through the air even more easily than older types. Notice that the blimp has a very smooth shape also.

In the earlier plane models the landing wheels did not fold up into the body. They hung down as the plane flew along.

The cover of the cockpit was higher than the body of the plane. Today the wheels fold up. Very little, if any, of the cockpit rises above the rest of the plane.

Their smoother shapes help aircraft, trains, and automobiles move through the air more easily, just as smoother shapes help boats move through water more easily.

## THINK ABOUT OR DO THESE THINGS

1. Ships and airplanes must be loaded very carefully so that they are well balanced.

Suppose a ship was carrying a load of sponges and oranges. What do you think would happen if all the sponges were loaded on one side of the ship and all the oranges were loaded on the other side?

2. Play on a seesaw with a friend. If your weights are different, you will have to move back and forth on the board before you will find the best balance.

3. Furniture must be built so that it is well balanced. Study the chairs, tables, and desks in your room. Why do they not fall over?

4. Examine the lamps in your home. Why do they not tip over easily? Floor lamps are often tall and narrow. You may wonder why they do not tip over. Notice the bases. Are they broad and flat?

5. If you have a chance to watch a ballet dancer, notice how she holds her body and arms so that she can balance on her toes.

6. Have you ever really noticed the design of your school building or of your house? Draw pictures of these two buildings. Did you remember their designs?

7. Make a collection of pictures of ships, automobiles, aircraft, trains, and birds in flight and at rest. Compare their shapes.

8. Think of trying to play tennis, baseball, basketball, or football if there were no gravity! What would happen?

9. If you wanted to fly to the moon or to Mars, you would have to travel much, much faster than any rocket or airplane has yet traveled. Why? If you could get near the moon, would you be pulled toward it? Why?

# Wind and Water Change the Earth

## Changing Rocks and Soil

Drip-drip-drip. Spatter-spatter. Pour-pour. Gently falling rain, torrents of rain. Slow-moving rivers, swiftly flowing rivers. Bubbling streams, pounding waves. Water wears away rocks year after year.

Ice moves slowly over the ground in the form of glaciers. This ice too wears away rocks year after year.

The moving air, carrying its load of sand particles, wears away rocks and stones, too. This wearing away goes on year after year. Sometimes the wearing away is greater in some years than in others. But year after year sand carried by moving air wears rocks away. Some rocks are carved into beautiful shapes by moving air and sand. Some rocks are made smooth and flat.

Streams and rivers move soil and stones about. Slow-moving glaciers also do their share. The ever-moving ocean moves sand and pebbles back and forth, back and forth. Winds blowing across the land also move the soil.

Wind and water, year after year, carve rocks and move soil and stones.

# Wind Wears Away Rocks

Moving air blows tiny pieces of soil about. Some of this soil is made partly of sand. Some of it is made almost entirely of sand.

Pieces of sand are very hard. This is especially true of sand made of the hard mineral called quartz.

Quartz is less hard than a diamond, but it is very hard. You may know that a diamond is so hard that it will scratch glass. So will quartz.

Here is a picture of a piece of quartz sand as it looks under a magnifying glass, or hand lens. Notice how sharp the edges are.

Can you see how sand will scratch rocks when it is blown by the wind? Year after year rocks are worn away by these hard bits of quartz.

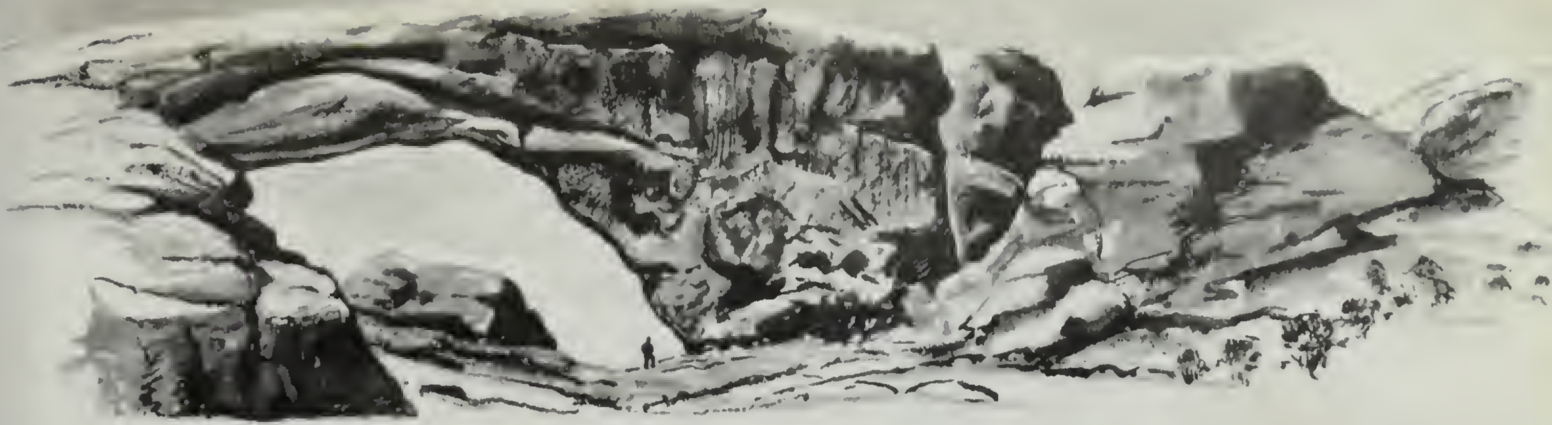
When the rocks are worn away, small pebbles and tiny bits of dust are left. The small pebbles and dust become a part of the soil.

You can make some dust from rocks. You will need two stones, one softer than the other. Rub the stones together. Do you get any dust?

If both stones are very hard, you will get only a little dust. But if you choose one softer stone, such as sandstone or limestone, soon you will have a small pile of dust.

Not only does wind-driven soil wear away rocks. It also wears away anything in its path.

Sometimes automobiles crossing the Mojave Desert in southern California during a sandstorm have had their paint scratched off by the wind-driven sand. Not only this, but windshields have been so badly scratched that one could not see through them.



Sometimes paint is scoured off walls of buildings by wind-driven sand. It is easy to see why a person would not like to be caught in a sandstorm!

Wind-driven sand has helped to make rocks beautiful. Above is a picture of an arch that has been carved out of sandstone. This arch is in the Arches National Monument in Utah.

People learned long ago that sand could cut and scour. People used sand for scouring the stone steps of their homes. They rubbed the sand back and forth with wet rushes.

Today man uses in another way this understanding about the way that sand can carve. He uses it when he uses sandpaper to smooth wood.

Sandblasting machines are used for cleaning brick and stone buildings in large cities. A blast, or stream, of air or steam is trained on the blackened, smoky stones of a building. Carried along by the stream of air or steam are pieces of hard sand. This sand scours the dirty bricks or stones. Smoke and dirt are softer than the sand. So they are scoured away bit by bit.

## Water Wears Away Rocks

Wind-driven sand is powerful in breaking up rocks and stones. But water is even more powerful.

Water wears away rocks day after day and year after year. It does its work in different ways.

Water falling as rain wears away rocks. So does moving water in streams and rivers. So does the moving water of lakes, seas, and oceans. When water freezes, it also helps to wear away rocks.

Sharp jagged stones

Water-smoothed stones

Let's think about some of the effects of water as it wears away rocks and stones. Have you ever picked up stones from a mountain stream? Some of the stones are sharp and jagged. But most of them are smooth.

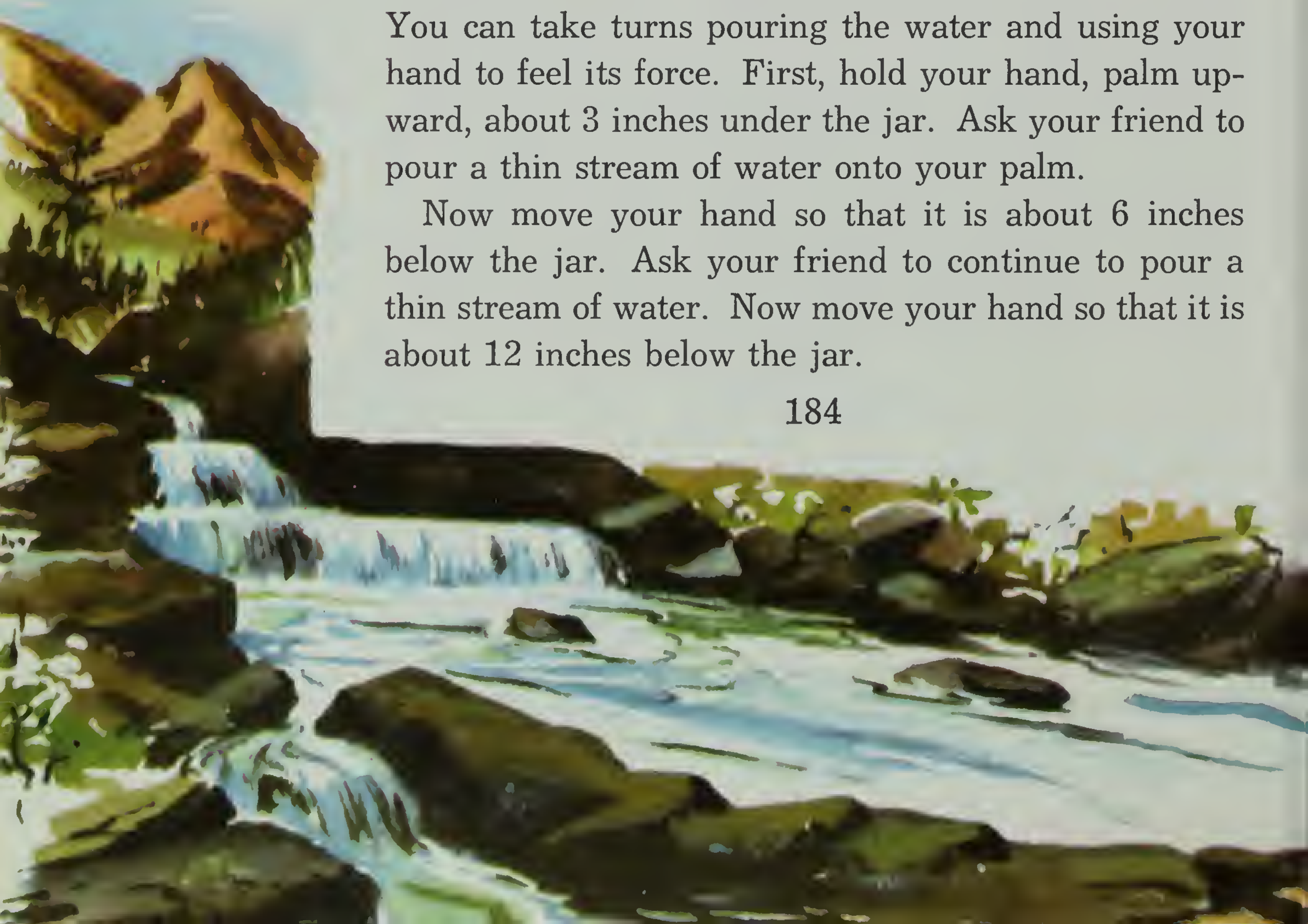
When these stones were first broken off the rocks, they all had sharp edges. But water helps to smooth the stones. The fast-moving stream causes the stones to tumble over one another. As they do this, small pieces are broken off, and after a while the stones become smooth. This wearing away may take many years.

Falling water also wears away rocks. This is because falling water has force. Here is an experiment to make this clearer: For the experiment you will need a jar or pitcher of water and a pan in which to catch the water.

Ask someone to work with you on this experiment. You can take turns pouring the water and using your hand to feel its force. First, hold your hand, palm upward, about 3 inches under the jar. Ask your friend to pour a thin stream of water onto your palm.

Now move your hand so that it is about 6 inches below the jar. Ask your friend to continue to pour a thin stream of water. Now move your hand so that it is about 12 inches below the jar.





Do you notice that the force of the water seems greater when your hand gets farther and farther from the jar? The amount of water falling is about the same. But falling a greater distance gives the water more and more force.

Now try this: Put your hand about 6 inches below the jar. Ask your friend to pour a thin stream of water. Now ask him to pour a heavy stream. Notice the difference in the force. Larger amounts of water have greater force.

Falling water is powerful. Have you ever noticed the soil under a dripping outdoor faucet? If the faucet drips and drips, the soil is moved.

Sometimes a stone is placed below an outdoor faucet. If the stone has been there a long time, it may have a rounded-out spot in it. This is where water has fallen on the stone many times. The water has worn away the stone.

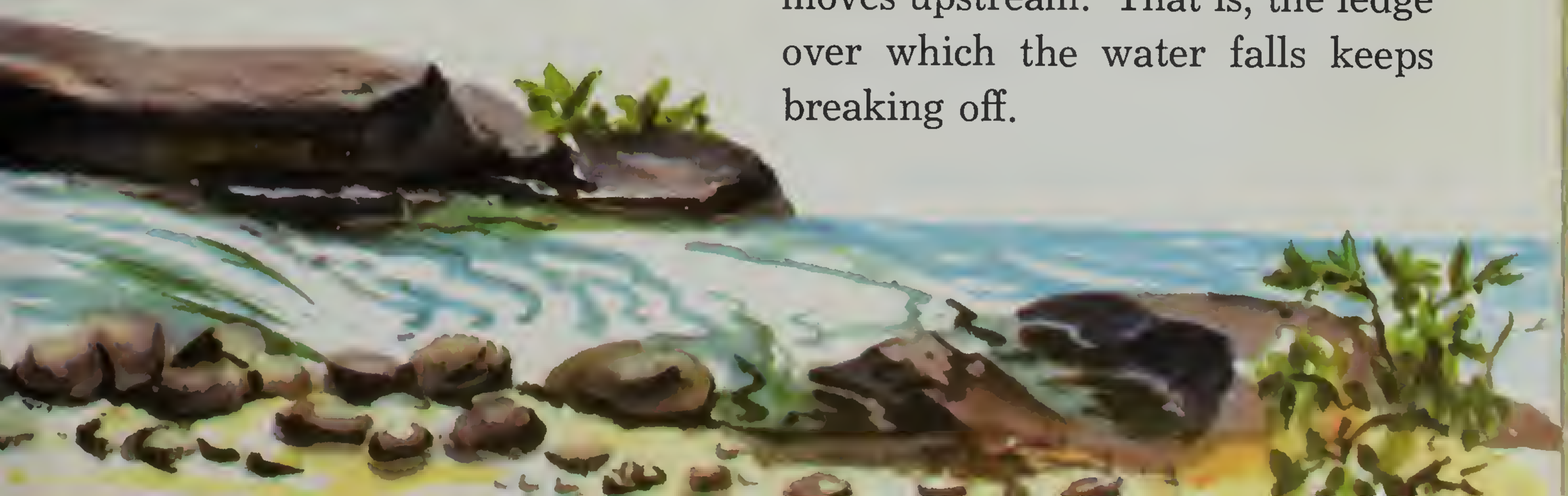
The beds of some streams are often made of smooth rocks, as well as pebbles and soil. The moving water of these streams, with its load of sand and pebbles, keeps wearing these smooth rocks.

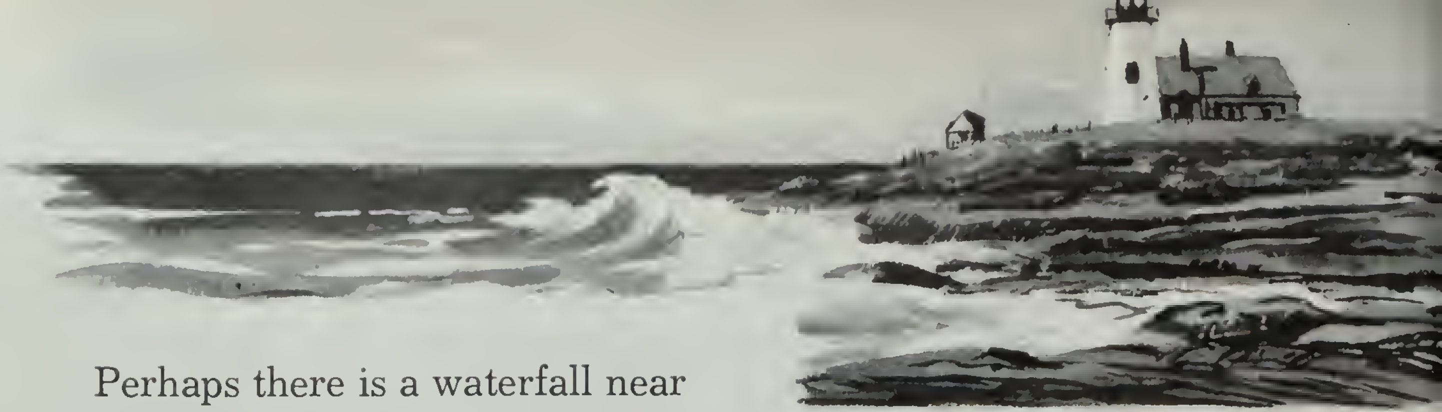
Sometimes round holes are found in these rocks. These holes are called potholes. If the rocks are very large, some potholes may be as large as a room; others may be only a few inches deep.

Potholes are made by falling water. A waterfall may wear away the rocks in the stream below the fall. Year after year this goes on until finally a hole is worn in the hard rock. Pebbles swirling around in the hole make it larger and larger.

Waterfalls wear away rocky stream beds in another way. As the water falls over a rocky ledge year after year, the rock is loosened. After a while a piece of rock will break off and fall into the stream.

This goes on year after year. It goes on so long that the waterfall moves upstream. That is, the ledge over which the water falls keeps breaking off.





Perhaps there is a waterfall near the place where you live. If so, ask your parents or your teacher if they can arrange for you to visit it.

You will want to observe several things. Notice how stones are tumbled about by the force of the water. If you watch a piece of wood or a leaf in the stream above the waterfall, you will see it carried over the falls. Perhaps you will even be able to locate some potholes in this stream.

Ask an older person in the neighborhood whether the waterfall has always been in exactly the same place. Try to find out if the waterfall is moving upstream.

One of the most interesting waterfalls in North America is Niagara Falls. The waterfall is in the Niagara River, which flows between Canada and the United States. This huge waterfall is about halfway between Lake Erie and Lake Ontario. Locate Niagara Falls on your map.

Niagara Falls are really two falls, the Canadian and the American falls. Find a picture of them. The Niagara River is about half a mile wide at this point. Think of the millions and millions of gallons of water that flow over the falls each day!

These falls are always moving upstream because the water is wearing away the rocks of the cliff over which it flows. They move upstream at the rate of 2 to 4 feet each year. Thousands of years from now there may be no Niagara Falls. The falls may have moved all the way back to Lake Erie.

Pounding waves also wear away rocks. Above is a picture of the wave-swept Atlantic coast. The rocks shown are very hard granite rocks. But the huge waves, pounding at these hard granite rocks year after year, have worn them away. And the waves will continue to wear these hard rocks away.

# Plants Break Rocks

It is easy to see that water will break up and wear away rocks. It is also easy to see that wind-driven sand carves rocks.

But perhaps you never thought about plants breaking up rocks. This is because we do not actually see plants growing. We do not realize how very powerful growing plants are.

Here is an experiment that will help to show that this is a fact: In a small pot of good soil, plant about ten corn or Lima-bean seeds. Water the seeds and put the pot in a warm, sunny place.

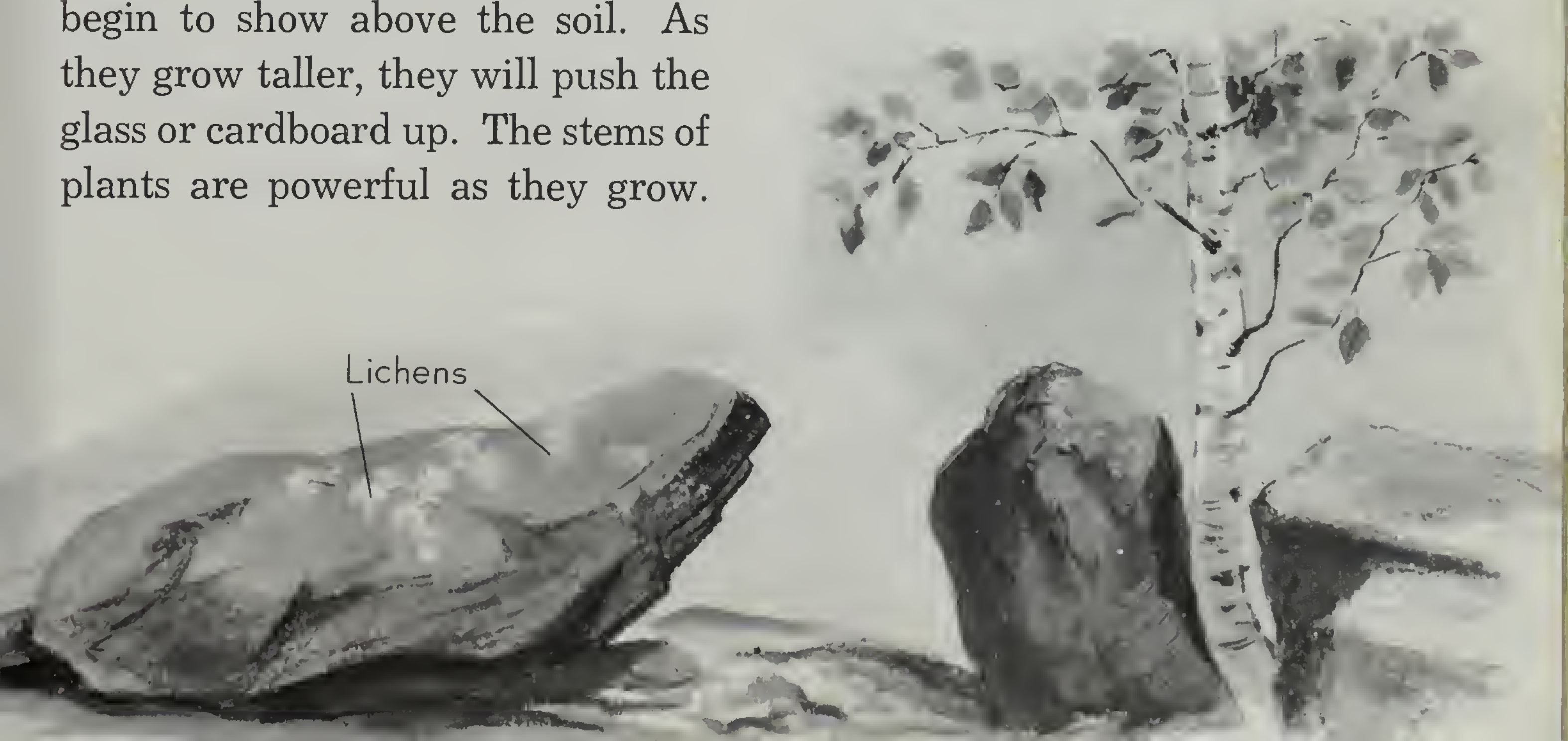
Lay a piece of thin glass or heavy cardboard on top of the pot. Each day you will need to lift the glass so that you may water your seeds.

In a few days young plants will begin to show above the soil. As they grow taller, they will push the glass or cardboard up. The stems of plants are powerful as they grow.

Sometimes tree seeds fall into cracks in rocks. If there is enough soil in the crack, a seed may begin to grow. Year after year the roots grow longer. Year after year the stem grows taller.

Slowly the growing tree forces the rock apart. The crack gets wider and wider. Finally, the rock is completely broken apart by the growing tree. Have you ever seen such a rock split apart by a tree?

Very small plants, such as lichens, also cause rocks to wear away. If you have ever scraped lichens off rocks, you may have noticed that small pieces of the rock chipped off, too. These plants cause chemical changes in the rocks. Then the rocks crumble.



## Heating and Cooling Changes Rocks

Rocks are quite solid. Yet heating and cooling may cause them to change. This is especially likely to happen if water in a crack in the rock is heated and cooled.

Water expands when it is cooled enough to freeze. You may have noticed this when you took an ice-cube tray from the refrigerator.

The ice cubes were not smooth on top. There was a little peak on each one. This was because the water expanded when it froze. The only place it could go was upward.

Have you ever brought in the milk from the back porch on a very cold morning? Had anything happened to the caps on the bottles?

Bottle caps are likely to be pushed up by frozen milk. Milk contains a great deal of water. So when milk freezes, it too expands.

Here is an experiment that will help you to understand even more clearly the power of freezing water: For this experiment you will need a pint fruit jar with a screw top.

Fill the jar full of water. Screw the top on tightly. Now place the jar outside in a shady place on a day when the temperature is several degrees below freezing. Or if the temperature is above freezing, put the jar in a plastic bag. Then put it in the freezing unit of a refrigerator or in a home freezer.

The water in the jar expands when it freezes. Since there is no empty place for the water to expand into, the jar will crack. The jar may break as you pick it up. So it would be a good idea to wear gloves when you do this. Then you will not cut your fingers.

Now you may be wondering what all this has to do with the heating and cooling of rocks.

Very often there are cracks in rocks. Rain falls and water gets into these cracks. Then, if the temperature falls below 32 degrees, the water freezes and pushes the rocks apart slightly.

On a warm day the ice will melt, but during the night the water may freeze again. This pushes the rocks apart still more. Little by little the rocks may be broken apart.

## Animals Wear Away Rocks

Have you ever noticed rocks that were worn away by animals? If you live near a farm where there are cattle or horses or goats or sheep, you may have a chance to see for yourself.

Animals walking over large, flat rocks day after day, year after year, sometimes wear away the rocks.

People also wear away rocks. Notice how old steppingstones or old stone steps have been worn away by the many, many feet that have walked over them year after year after year.

## Wind Moves the Soil

Wind moves the soil about. You have certainly noticed this on a windy day. Dust is whirled here and there by the wind. It gets into your eyes. It stings your face.

The soil that is blown about by wind is loose soil. That is, it is soil not held down by grass, trees, or other plants.

Here is an experiment that will show how grass helps to hold down the soil so that wind will not blow it about so easily:

For this experiment you will need two boxes. These boxes should be wooden ones and rather flat. The kind of boxes in which cherries or plums are packed would be just about right.

You will also need newspaper, grass seed, soil, water, and an electric fan. First, put several layers of newspaper in the bottom of each box. Now add soil to each box, filling the box to within 1 inch of the top.

Sprinkle grass seed on the soil in one box, but not in the other. If you can't get grass seed, use birdseed. Birdseed is partly a collection of certain kinds of grass seed. Now smooth the soil.

Water the soil in each box each day. Pull up any plants that may sprout in the box that you left unplanted. When the grass is about 2 inches high, you are ready for the rest of the experiment.

Wait for a still day. Do not water the boxes on this day. Take the boxes out of doors and also take the electric fan. You will need a long extension cord so that the fan may be turned on out of doors.

Ask the custodian to help you with the fan. Set the box with the grass seed in front of the fan and level with it. You may have to put another box or some bricks under the planted box to make it high enough. Turn on the fan. Notice that some of the soil is blown away.

Remove the planted box and put the unplanted box in its place. Turn on the fan. Watch out! Don't let the soil blow in your eyes. Note how much more soil is blown away.

Sometimes soil is blown about so much that great damage is done. In the 1930's there were some great dust storms. Much soil was blown away from southern Manitoba, Saskatchewan, and parts of the central United States.

So much soil was blown by the wind that a great dust cloud drifted far out over the Atlantic Ocean.

Dust is blown about a great deal on the dry, desert lands. This often happens in the desert regions of California, Arizona, Nevada, and Utah. It also happens on such a great desert as the Sahara. Dust from the Sahara has even been carried all the way across the Mediterranean Sea to France.

Sand near the seashore is often blown about by the wind. On very windy days it is uncomfortable at the shore for this reason. Sand stings your bare arms and legs. It is blown into your food.

Sand is blown into small hills, or dunes. Sometimes these dunes become so large that they cover trees and even houses.

The earth's surface is always changing. One reason for this is that year after year wind moves the soil about.

## Water Moves the Soil

Water is also a mover of soil. If soil is protected by plants, it is not moved as much by water as unprotected soil. You might like to try an experiment to see if this is true.

For this experiment you will need two flat, wooden boxes, newspaper, water, grass seed, a watering can with a sprinkler spout, and some good soil.

First, put several layers of paper in the bottom of each box. Now fill the boxes with soil to within 1 inch of the top. Plant grass seed or birdseed in one of the boxes. Water both boxes each day. Let the seeds grow until the grass is about 2 inches high. Now take both boxes out of doors. Prop each box with a brick under one end so that the box slants. Now water the box where the grass is growing. Hold the watering can about a foot above the high end of the box.

Notice that some soil is washed out of the box. You can see just how much soil this is if you catch the water in a pan when it runs out of the box. Let the water evaporate and notice how much soil is left.

Do this same thing with the unplanted box. Notice how much more soil is moved by the water!

You will be able to find many places in your neighborhood where soil has been washed away by water. Here is a list, made by children in one community, of ways in which water moves the soil:

1. A new house is being built. The weeds and grass were dug up by the builders. After a rain much soil was washed into the street. The soil was carried into the gutters by the running water.

2. Daddy had new topsoil put on our lawn to help the grass grow better. There was a heavy rain. Now much of the topsoil is gone. It was washed away by the water.

3. The brook near our house is very muddy today. There has been a lot of rain lately. Soil has been carried into the brook by water moving over the soil into the brook.

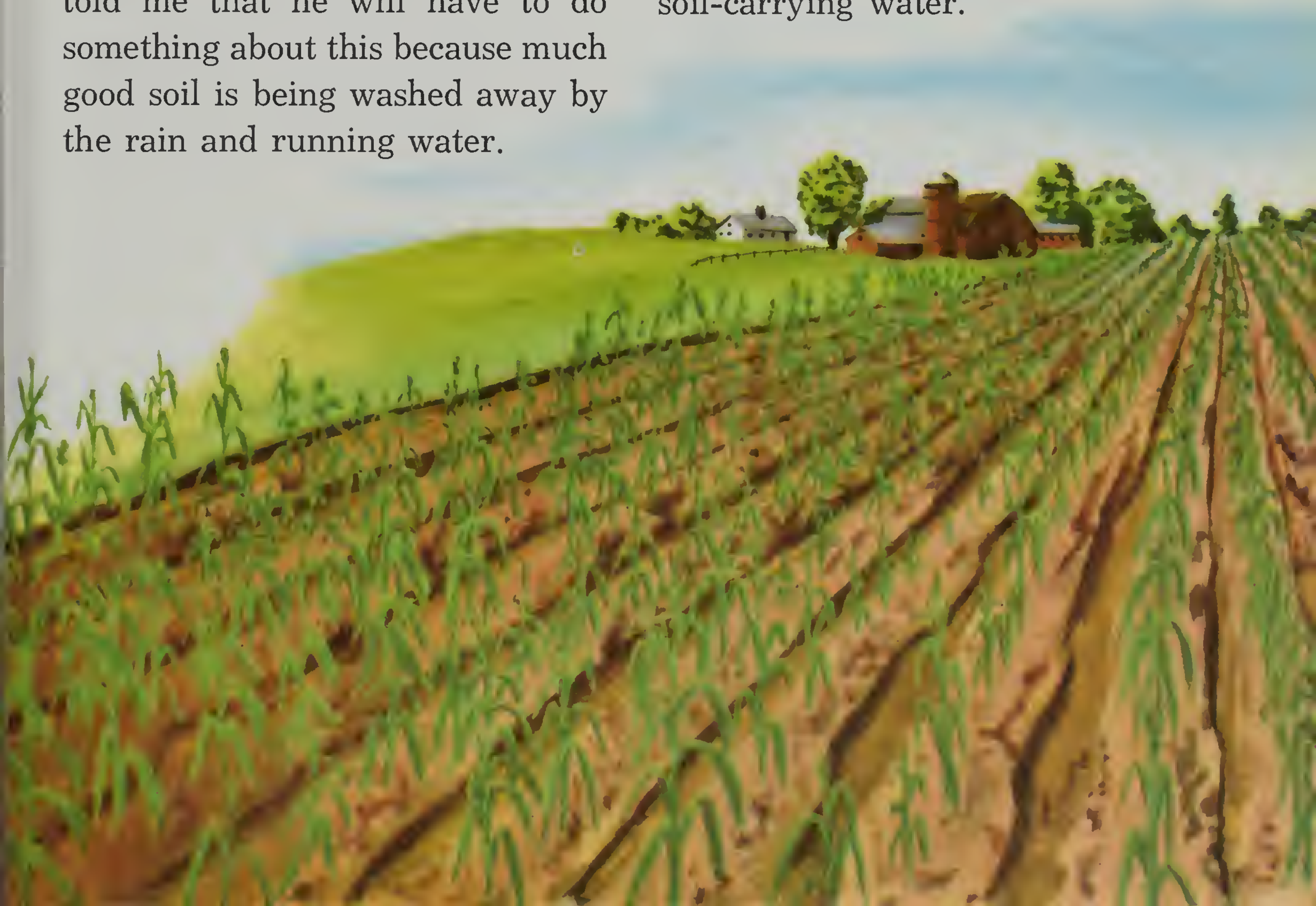
4. There is some new soil on our lawn. Our house is at the bottom of a hill. Rain has washed some of the soil from the hill above our house. The soil has stayed on our lawn because it is flat and planted with grass.

5. We drove up into the mountains on Sunday. We had our picnic by a mountain stream. It was easy to see how this stream carried soil and stones. It was moving so fast that it just bumped the stones along.

6. Last week end we went to visit my uncle on his farm. He is very worried about his land because it is being washed away by rain. He told me that he will have to do something about this because much good soil is being washed away by the rain and running water.

7. Daddy ordered a load of gravel for our driveway yesterday. A lot of the gravel was washed away in the big storm. Daddy says we will have to build a curbing around the driveway to hold the gravel.

These are only a few of the ways in which water washes away the soil. Sometimes a great deal of soil is moved by large rivers. When a river is in danger of overflowing, men build dikes of sandbags to hold the river in its bed. But this does not always work. Sometimes the water swirls over the dikes and washes away much soil. The water may appear muddy because it is soil-carrying water.



The ocean also moves sand and pebbles. Have you ever been at the shore before and after a storm?

Before the storm the beach may have looked like the first picture below. There were very few pebbles to hurt your feet.

The second picture shows this same beach after a storm. Wind has whipped the water into huge waves. It has moved the water on the bottom as well as the water near the top of the ocean.

The huge waves have pushed up stones from under the water onto the beach. Here some of the stones have been left by the moving water. Here they will stay unless a high tide takes them out to sea again.

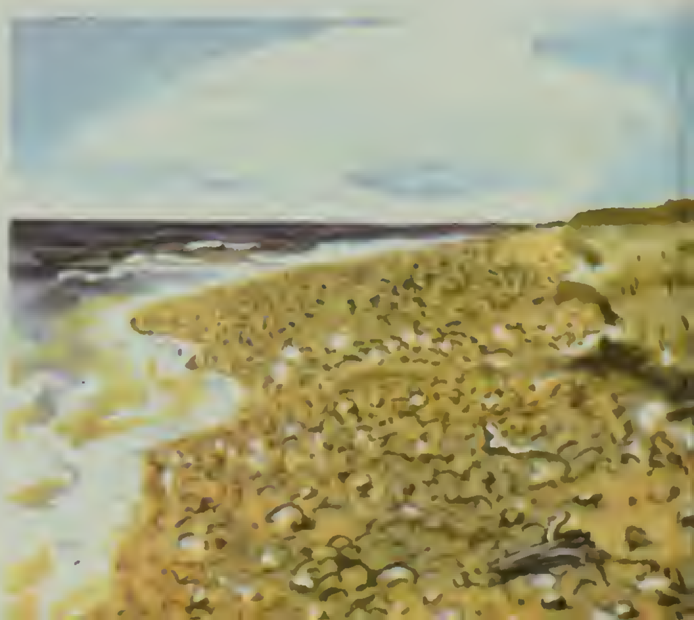
If you have been to a beach summer after summer, you may have noticed another thing. You may have noticed sand bars appear and disappear.

Sand may be moved by the water to one place on the beach during the winter. The next winter the moving waves may cause this sand to disappear. The sand bar has been moved away by the ever-moving water of the sea.

Sand bars may appear and disappear along lake shores too. A sand bar also may be formed where a river or stream flows in a curve. This is often true of a slow-moving river. The bar of soil or gravel or sand is built up on the inner side of the curve.

Very large deposits of soil may be built up at the mouths of rivers, especially slow-moving rivers like the Mackenzie or the Mississippi. Such a deposit is called a delta.

Soil has been washed from fields and forests. It has then been deposited by the slow-moving river to form a delta.



## Frozen Water Moves Soil and Stones

An interesting time to explore the edge of a lake or stream is in the spring. Not only will you see many signs of plant and animal life, but you may also see some of the effects of frozen water.

If the lake or stream has been frozen over during the winter, you will be able to see how this frozen water loosened and moved the soil.

When the water at the top of the lake froze in the winter, it expanded. The expanding ice pushed against the soil. It moved the soil up a bit along the shore. Then, as spring came, the ice melted. The loosened soil began to crumble and fall into the water.

Sometimes only a few inches of soil is loosened along the water's edge. But sometimes a foot or even several feet of soil may be loosened all along the edge.

In some parts of North America where the temperature often goes below freezing, much snow may fall. Some of the snow melts in the summer, but much of it does not. This snow may form a glacier.

Glaciers move downhill very, very slowly. Some move only a few inches a year. Others move a few feet a year. But as they move, they carry along soil and stones.

Some of the stones are frozen into the bottom of the glacier and are carried in this way. Others are pushed along in front of it.

The Mendenhall Glacier, shown in the picture above, is near Juneau, Alaska. This glacier is more than 300 feet high, or about as high as a 25-story building. How much soil and stone this glacier has moved!

Glaciers are powerful movers of soil and stones.

## Slowing Down the Work of Wind and Water

It is important to each one of us, no matter where we live, that the work of wind and water should be controlled. This must be done if we are to have enough food to eat and clothing to wear.

Plants that we use for food and clothing grow in the soil. But these plants must have good soil in which to grow. If the soil is washed away year after year, soon there may not be enough good soil for our plants.

Animals that we use for food and clothing depend on plants for food. If there is not enough soil in which the plants may grow, then there may not be enough cattle and sheep and pigs to give us food and clothing.

Because man is able to think and plan, he has made and continues to make plans to control the work of wind and water.

A good farmer understands and uses good ways to control the work of wind and water on his land. Let's see what some of these good control methods are.

If you have visited the prairie provinces of Alberta, Saskatchewan, or Manitoba, you know that winds blow and blow over the broad, flat land. Farmers often protect their homes from the full force of these winds by planting clumps of trees, known as windbreaks.

In the picture above, trees have been planted to shelter the farmhouse and other buildings. Of course these trees do not stop the wind entirely. But they cut down its force. Such windbreaks are planted on the side of the house and other buildings toward which the winds blow most often.

Farmers have also learned about special ways of plowing their land and planting their crops.

The picture above shows what a farmer may do to control water on his land. First, he may contour-plow his land. This means that he studies his land to determine the roll of the land before he plows.

Then he plows with the curve of the land rather than against it. He does not plow furrows that run up and down the hills. This would allow the rain to wash away soil easily. He plows around the hills, so that his furrows curve with the land. Can you see how this method of plowing helps to hold the soil?

The farmer has also learned to plant crops in strips. He may plant a strip of corn, then a strip of oats, and then a strip of hay.

This means that the farmer's crops will mature at different times. Because of the different times of maturing, each crop will be harvested at a different time.

Planting crops in this way is very important because it means that some crop is always growing. If heavy rain falls after one crop has been harvested, some of the soil will be washed away. But it will be washed onto the next strip, which will hold the soil because plants are growing there.

Farmers no longer clean off their land completely in the winter. In some places on their farms they may leave stubble, or stalks of crops, in the fields. The stubble holds back the water from the heavy winter rains and snows and so helps to hold the soil on the land.

The men and women who work in the Soil Conservation Service in your state or province and in your county are of great help to the farmers. They give them suggestions on ways of controlling the work of wind and water.

Soil conservation has been followed in some lake and ocean areas. Because of this the sand has been kept from blowing away badly.

Above is a picture of a beach that has been planted with dune grass. This tough, hardy grass grows well in sand. It is not a good crop plant, but it keeps sand from blowing.

Great amounts of soil may be washed off the banks along roadways. To stop this, grasses are planted to hold the soil. In some places roses are planted along the banks. Grasses, roses, and other plants are called cover plants when they help to hold the soil.

Kudzu is sometimes planted in badly washed fields. This plant has long, vinelike roots, which hold the soil and keep it from washing away. Kudzu is not only a good cover plant, but a good cattle food too.

Lespedeza is another good cover plant. This light-green plant with a bushy top grows several inches high. Its roots keep the soil from washing away. Its bushy top slows down the rain.

Lespedeza is planted between strips of corn to help hold the soil. It is planted in pastures to hold the soil and furnish food for cattle.

These are some of the good practices that farmers follow today. Visit a farm and ask to see these and other ways in which wind and water are controlled.

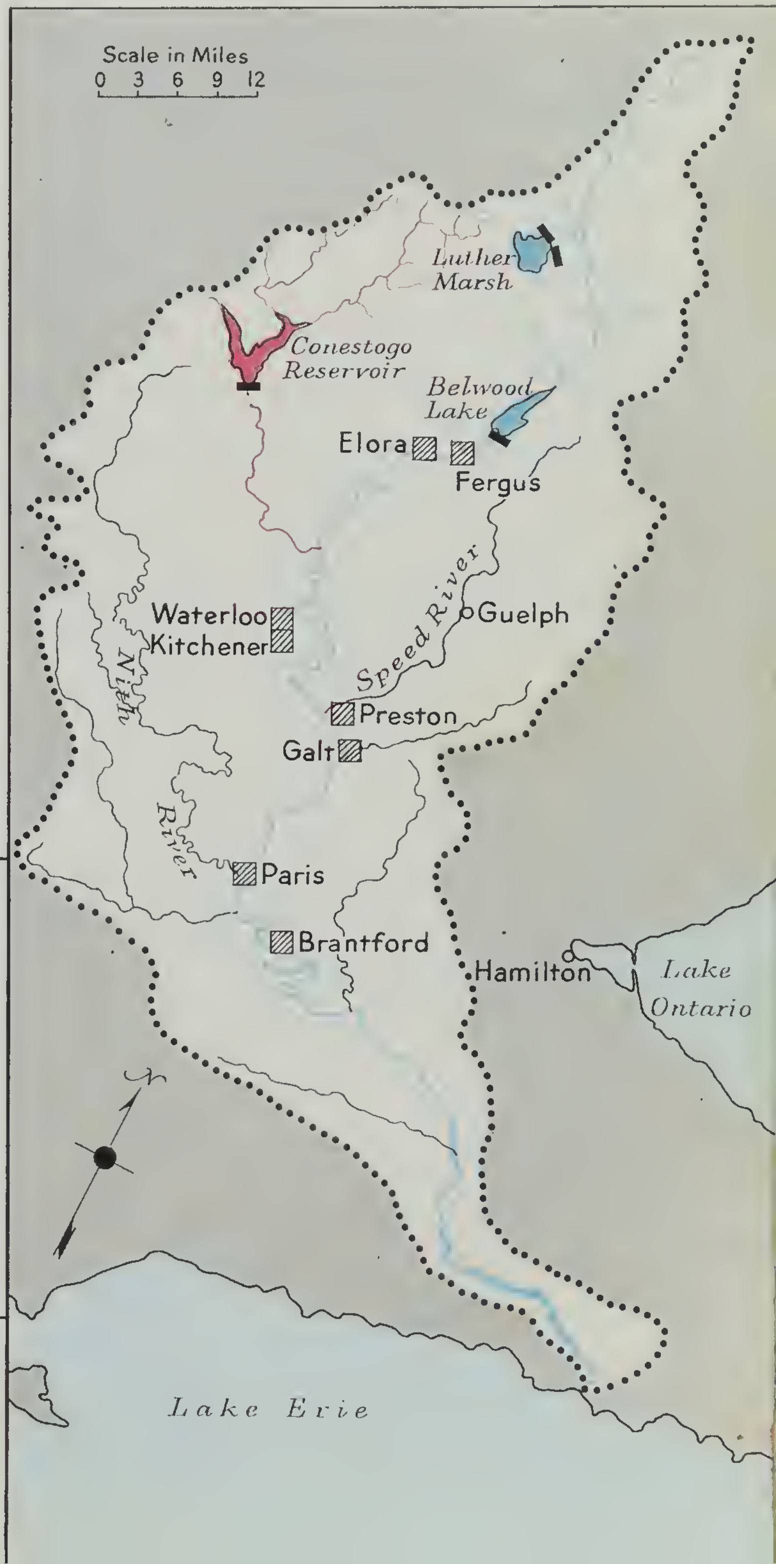
# Systems of Dams Hold the Floods

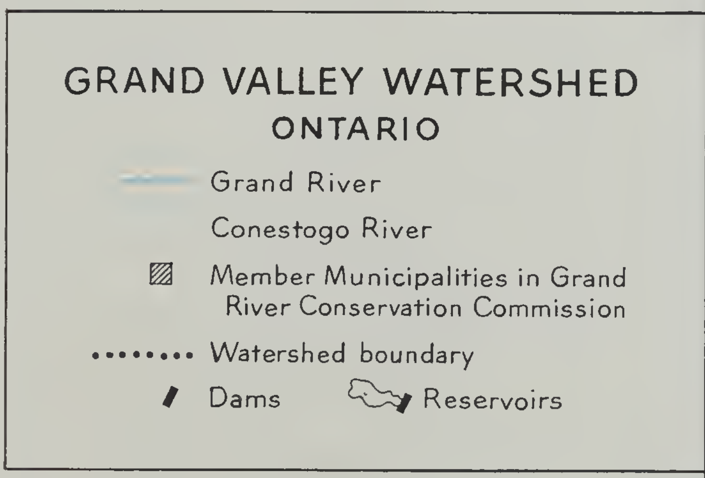
In some places rivers have caused much damage when they have overflowed their banks. Crops have been washed out. Homes have been flooded or even washed away. Farm animals have been drowned.

Along some rivers, such as the Red and the Fraser, dikes have been built. Dikes are a kind of artificial riverbank. They are built of earth or concrete. Sometimes sandbags are laid on top of them to make them higher.

During the worst floods these dikes have not always held back the flood waters. The roaring, swirling waters have washed away the banks of earth. They have risen above or broken through dikes. Then they have spread out over the land.

So along some rivers, systems of dams have been built. One interesting system of dams has been built in southern Ontario. The locations of these dams are shown on the map below.



These dams can be controlled so that the amount of water flowing down into the lower reaches of the Grand River is regulated. This helps in controlling floods.

Of course this one system of dams will not control all the flood waters of the Grand River. But it will control some of the flood waters until other dams are built.

Another purpose served by these dams is to provide a steady supply of water all year round. This is good for agriculture, woods, and wildlife. It also makes the area a good place for outdoor recreation.

In the United States some vast systems of dams have been built to control flooding along such rivers as the Ohio and the Tennessee.

The great Tennessee River runs through the states of Tennessee, Alabama, and Kentucky. Dams controlling the flood waters of the Tennessee River also help the Mississippi. This is because the Tennessee empties into the Mississippi.

The Wisconsin River has a series of dams also. These dams help to control the flow of the water. This is true of other rivers, such as the Colorado in Texas and the Columbia in Oregon and Washington.

The use of dams, then, is another way in which men try to control the work of water. Wind and water break rocks into stones and soil. Then these are moved over the surface of the earth. Too much moving of stones and soil is bad.

## PLAN TO DO THESE THINGS

1. Take a look around your school grounds. Is the water washing away the soil? Is there anything you can plan to do to stop this?

Talk over the possibility of using low-growing plants to hold the soil. Is soil running off your playing field? Why? Can anything be done about it?

2. Visit a quarry. Notice that the stones at the edges of the quarry have crumbled. Some of them have crumbled because they have been exposed to wind and water.

Notice that stones deeper in the quarry are hard to get out. Wind and water haven't had much chance to work on these buried stones.

3. Select a committee to write to the soil-conservation agent of your county. Ask him if you may borrow a farm map. Such a map will show you how a farm is studied so that it may be plowed and planted correctly.

4. If there is a forest or woods nearby, try to visit it. Dig gently into the soil of the woods. First, you will dig through leaves. Then you will find rich, moist soil.

The soil of woods and forests is moist. The leaves that have fallen year after year help to hold the water. The roots of trees help to do this, too. Do you see why it is a good thing to grow a cover of trees over our hillsides?

5. Find out if there is a plan for building dams in rivers or streams near where you live. Perhaps you will be able to visit a dam that has been finished.

Arrange to talk to the person in charge. Find out some of the reasons why the dam was built.

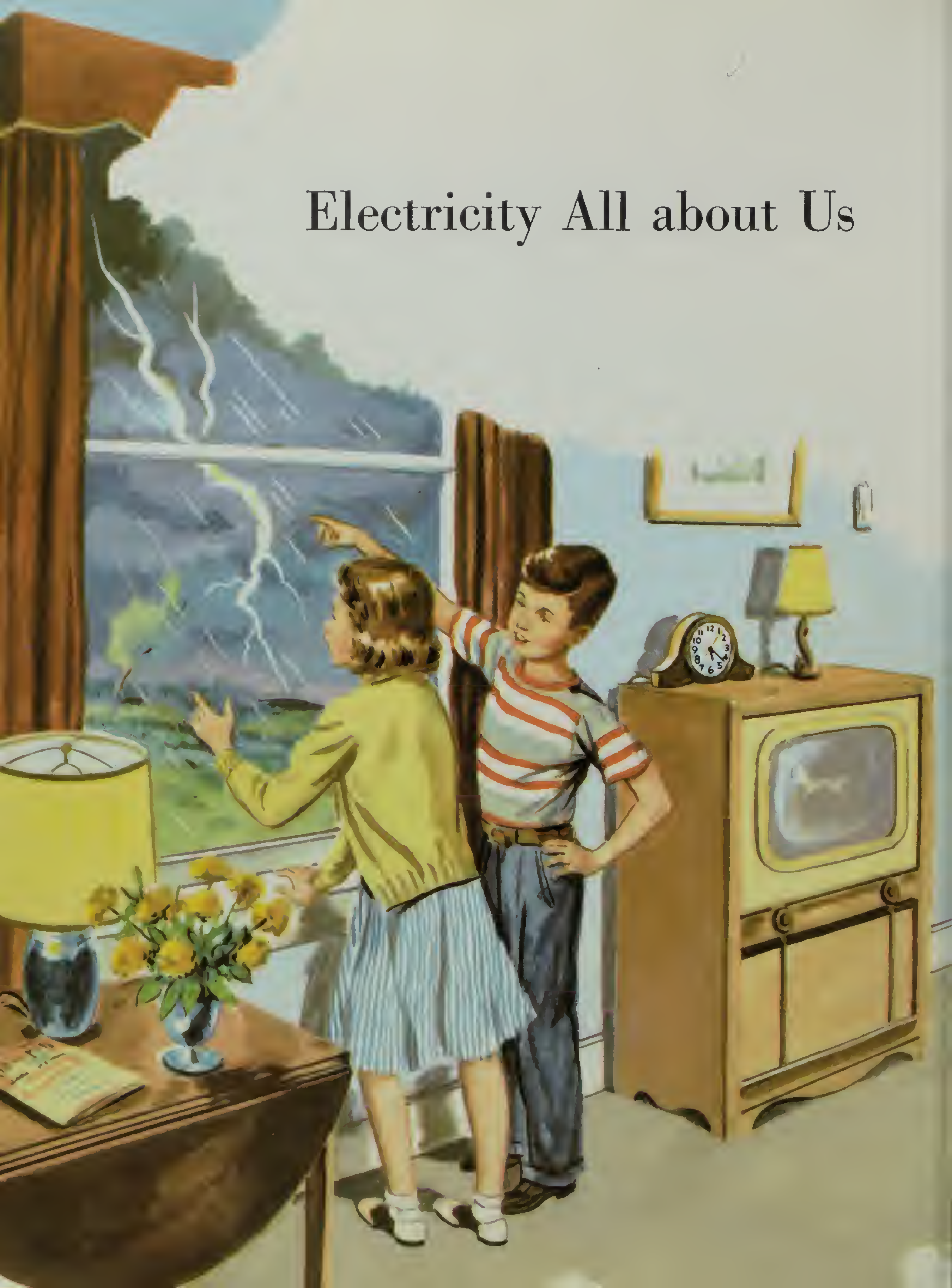
6. If you live in a city, visit a park to see some of the effects of water on the soil. List as many as you can.

7. Choose a piece of sloping land to watch for a period of a month or six weeks. Visit this slope every two or three days to notice the effect of running water on the soil.

8. Build an outdoor map of a section of North America. You will need stones and soil. Build up mountains and hollow out valleys. Make some smooth, flat lands. Plant grass and other seeds in the soil.

Watch the effect of rain and running water on your map.

# Electricity All about Us



# A Summer Storm

In the distance there is a low roll of thunder. Now it becomes louder. There is a flash of light! Again a bright flash of light in the distance and the sharp crack of thunder. A thunderstorm is approaching on a bright, hot June afternoon.

As the heavy clouds come swirling overhead, the sky becomes darker and darker. The lights in the room now have to be turned on. The bright flashes of lightning seem quite different from the steady light in the room.

The light of lightning and the light from an electric-light bulb are alike in one way. In each case the light is caused by electricity. The clock, the lamp, and the television set also use electricity. Let's find out more about electricity in the air and electricity in wires.



# Electricity Can Be Caused by Rubbing

The two children in the picture below are working with electricity. They are not working with electricity in wires. They are working with the electricity that is in the air.

You have done this, too. But you may not have known that you were working with electricity.

On some days it is hard to make your hair stay in place when it is combed. It seems to stand on end. This is because electricity has moved from the air to your hair. Then some of the electricity moved from your hair to the comb. You will find that this often happens on a dry day, especially if your hair is very clean.

If you listened as you combed your hair, you probably heard tiny crackling sounds. These crackling sounds are something like very tiny thunderclaps.

As you were combing your hair, you were really making very small sparks. If you are interested in seeing these small sparks, do this experiment: You will need a comb, a mirror, and a dark closet.

Go into the closet and close the door. Hold the mirror in front of your face. Then comb your hair with quick strokes. Did you see little sparks of light in the mirror? Did you hear the little crackling sounds made by the sparks?



Electricity that is caused by rubbing is called frictional electricity. You caused frictional electricity by combing your hair. Rubbing your arm over paper also causes frictional electricity.

An electrified comb will pick up small pieces of tissue paper. An electrified piece of paper will stick to the wall. Try the things the boy and girl shown on these pages are doing. Were you able to cause frictional electricity?

Lightning is also frictional electricity. It is caused when droplets of water are whirled about by strong currents of wind. After enough electricity has gathered in one part of a cloud, there may be a flash of lightning.

The lightning may move to another part of the same cloud. Or the lightning may move to another cloud or to the earth.

Wherever the lightning moves, it moves through air very, very fast. It travels thousands of miles in one second. This rapid movement of electricity heats the air.

You know what happens when most things are heated. Yes, they grow larger. We say they expand.

When the air is heated by lightning, it expands. The expanding, moving air makes a very quick, rushing movement. This movement causes the noise called thunder.

When you combed your hair, you also heard crackling noises. These noises were made by tiny sparks of electricity moving through the air. The sparks heated the air, and so it expanded quickly. When the air moved rapidly, you heard it.

It is fun to make electricity with cat's hair, or fur. Take your cat into a dark closet and stroke its fur. Do you see the tiny sparks and hear the crackling noises?

Did you ever get a shock when you touched a metal doorknob or a radiator or a person? Did you ever get a shock when you touched the handle to close the door of an automobile?

These shocks are caused by frictional electricity. When you walk across a wool rug on a cool, dry day, electricity from the rug moves into your body. Then you touch a doorknob or a radiator or perhaps a person. You feel a shock.

And if you touch a person, so does the other person get a shock! Electricity has moved out of your body. It has moved to the doorknob or the radiator or the other person.

Much the same thing happens when you slide into or out of a car seat. Electricity from the car seat goes into your body. You get a shock when you touch the metal door handle.

If you want to feel less of a shock, put your whole hand on the doorknob, not just a finger. Electricity moves into the doorknob from all parts of your hand that touch it. When all the electricity moves out of your body through one finger, it hurts. But when the electricity moves out through five fingers and your palm, it does not hurt, since part moves through each finger.

Do you make your own bed? Then you probably know another way of causing sparks of electricity and small crackles of sound. As the woolen blankets are separated, this happens.

These are some ways that frictional electricity may be caused. Think of other ways of causing frictional electricity.

Now let's try another experiment. For this you will need a comb, some woolen cloth or a woolen sweater, paper clips, thumbtacks, and tiny pieces of tissue paper. Put the tacks, clips, and paper in one pile on your table.

Rub the comb with the woolen cloth or rub it against your woolen sweater. Hold the comb just above the pile of clips, tacks, and bits of paper. Did the paper jump up to the comb? The moving of the paper to the comb is called attraction.

You caused frictional electricity by rubbing the comb with the cloth. The comb will now attract paper.

Try attracting bits of straw or threads with the comb. Does it pick these up?

A magnet will be needed for the next part of the experiment. Hold the magnet over the pile of paper, tacks, and clips.

This time the paper is not attracted, but the other things are. Magnetism is different from frictional electricity. Magnets attract things made of iron or steel, but they do not attract things made of paper or straw or hair or threads.

Try different magnets to see whether this is true of all of them.

Magnets keep their magnetism a long time. You may touch them, but they will still keep their magnetism. But this is not true of things which have frictional electricity.

Test this fact by the following experiment: Rub the comb with the wool. Now see if it picks up bits of paper. Yes, it does.

Next ask a friend to touch all parts of the comb with his hand. Put the comb near the paper again. The comb does not pick up the paper. The paper is not attracted to the comb.



Think of reasons to explain why this happened. Yes, the electricity moved from the comb into your friend's hand. Then the comb no longer attracted the paper.

Test the magnet to see if it still attracts clips and tacks. Now ask your friend to rub his hand over the magnet. Test the magnet again. It still picks up the clips and tacks. Magnets do not lose their magnetism when they are rubbed.

Frictional electricity will move out of a thing, such as a comb, into a conductor of electricity. Our bodies are good electrical conductors. That is why electricity moved into your friend's hand.

Water is also a conductor of electricity. Here is a way to show that this is true: First, turn on a thin stream of water at the tap.

Then rub your comb with wool. Bring it near the stream of water, but do not let it touch the water. Watch the stream move toward the comb. The comb is attracting the tiny droplets of water in the stream as they move past the comb.

Now let the stream of water run over the comb. Then hold the comb so that it is near the stream, but not touching it. The stream of water is no longer attracted to the comb. Electricity has gone into the water. The water from the tap is a conductor of electricity.

Metal is also a conductor of electricity. Rub your comb again and test it with the bits of paper. Now rub the comb over the metal radiator. Test it again with the paper. Has the comb lost its electricity? Where did it go?

Next you will want to test your magnet with water and metal to see if these things cause it to lose its magnetism.

First, see if your magnet will attract the clips and tacks. Now let water flow over the magnet. The wet magnet still attracts the clips and tacks. Water does not cause a magnet to lose its magnetism.

Magnets will even attract the clips and tacks through water. Put clips and tacks in a glass of water. Lower the magnet into the water so that it is just above the clips and tacks, but not touching them. Notice that they are attracted to the magnet through the water.

After you have finished experimenting in this way with your magnet, be sure to dry it so that it will not rust.

Now you will want to test your magnet to see whether or not it loses its magnetism to metal. Rub the magnet against the radiator. Does it still attract the tacks and clips? What does this show?

Did you know that you can also produce frictional electricity by rubbing glass? For this experiment you will need a piece of window glass, two books, small pieces of tissue paper, and some silk cloth.

Put the books on the table about 6 inches apart. Let the piece of glass rest on the books.

Place the pieces of paper on the table directly under the glass. Now rub the glass with the silk cloth. Do the bits of paper jump up to the glass? Why did this happen?

Producing frictional electricity on balloons is fun, too. Blow up two balloons to about the same size. Tie them with thread so that the air will not leak out. Hang them from the end of a stick.

Rub one of the balloons with a woolen cloth or sweater. Ask a friend to rub the other balloon with a woolen cloth or sweater. Now let go of the balloons. Do they stand apart?

This is because each balloon is made of the same material and was rubbed in the same way. The same kind of frictional electricity has been produced on each balloon. So they push each other away. Rub your comb with wool and bring it near the balloons. Why do they move away? Was the comb also rubbed with wool?

Test your balloons to see if they will attract bits of paper. Put some pieces of paper on a book and bring the book near a balloon. Is the paper attracted to the balloon? Why?

All along we have been saying that experiments with frictional electricity will work best on a dry day. Let us see why.

On a damp day there is much water in the air. In some places almost all days are damp.

It is hard in such places to produce frictional electricity. Electricity moves away from such things as wool and combs and glass to the water droplets in the air, since water is a conductor of electricity.

At first you may have thought that frictional electricity and magnetism were the same or very much alike. Think of the ways that you now know in which frictional electricity and magnetism are different.

## Protecting Ourselves from Lightning

Lightning can cause great damage. It can set trees on fire. Sometimes whole forests are burned in this way.

Lightning can strike chimneys and cause them to tumble down. It can kill animals and people.

But we need not fear lightning if we know and use ways of protecting ourselves from it.

One of the safest places to be during a thunderstorm is in a modern office building or apartment house. Look at the picture and try to think of reasons why this is true.

The building may be struck by lightning, but good conductors allow the electricity to move harmlessly into the ground. The steel girders of the building are the conductors that allow this to happen.

People who live on farms often put lightning rods on their homes and barns. Lightning rods can be a protection if they are properly installed and taken care of.

Study the picture below. Lightning rods, made of metal, have been placed on the house and barn. Notice that the metal rods on the house are higher than the chimney. Now, if lightning strikes, it will strike a metal rod instead of the chimney or some other part of the house.

The metal connection that goes from each rod down into the ground is a good conductor of electricity. It goes all the way down into the damp earth.

Trace the path of the lightning. It may strike a rod. Then it is conducted down through the metal into the damp earth, which is also a good conductor of electricity. Here the electricity spreads out harmlessly into the ground.

If there is a break in the metal conductor, the lightning can move into the house. If the metal conductor does not reach into the damp earth, the same thing can happen. Lightning rods should be checked often to see that they are in good condition.

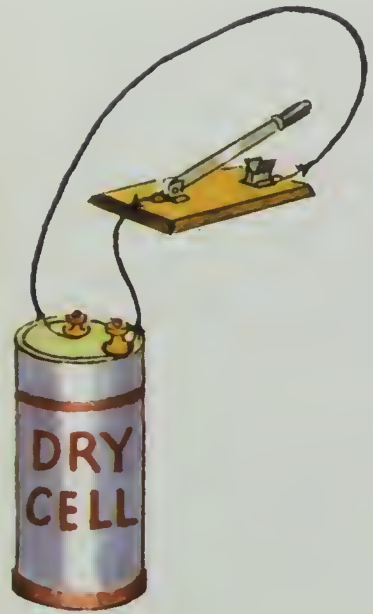
One of the worst places to be during a thunderstorm is under a tree that stands alone in a field. Since the tree is tall and is connected with damp earth, it makes a good conductor. If you are near the tree, electricity may go into your body.

Nor is it wise to stay in swimming during a bad thunderstorm. The water is level, and your head is raised. In this way you make a good target for lightning.

Should you stay out on a baseball diamond? Should you try to take a flag down from a flagpole? Why not? We can be safe from lightning if we know what to do.

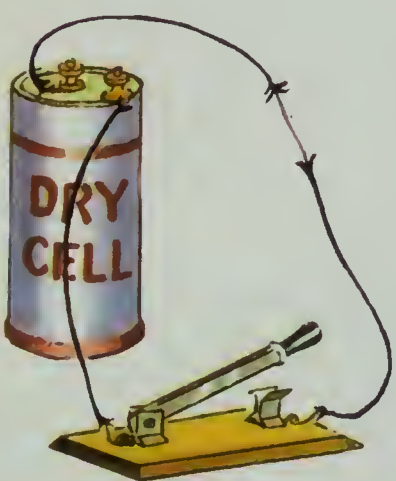


# Electricity Causes Heat




Have you ever touched the outside of a radio cabinet after the radio has been used for a while? Have you put your hand near an electric-light bulb after it has been lighted for a while? Have you put your hand above a toaster after it has been turned on? You found each of these things either a little warm or quite warm. Electricity has heated them.

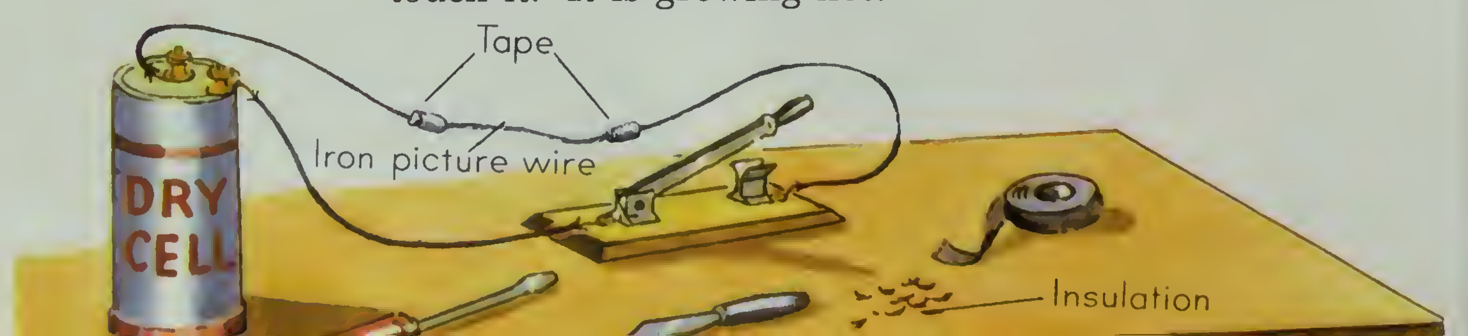
If you can get together the things shown on this page, you will be able to do experiments showing that wires are heated by electricity. Make a list of the things you will need. Did you put down dry cell, switch, insulated copper wire, iron picture wire, tape for insulation, knife, and screw-driver?



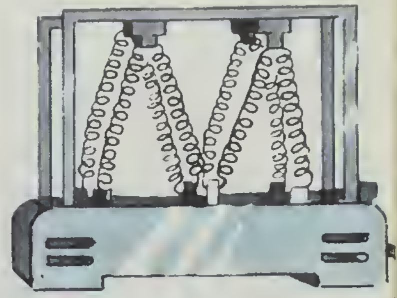

Study the first picture on this page. To make this circuit, you will need two pieces of the insulated copper wire. Each piece should be about 18 inches long. Be sure to scrape the insulation off the ends of each wire. Be sure all the connections are tight.

Feel the wires in your circuit. They are cold. Now press down the switch. Feel the wires again. Be careful! The wires are getting hot.

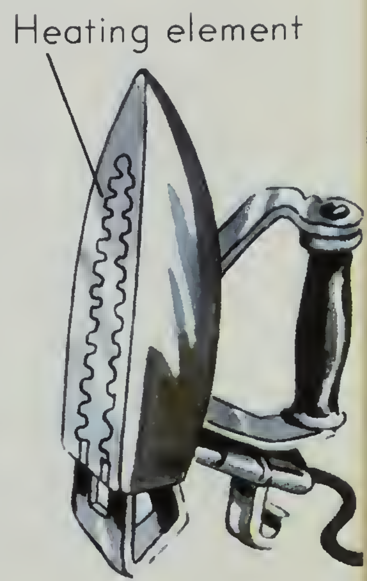
For the next circuit you will need the same materials as before. But this time scrape off part of the insulation in the center of one of the wires, as well as at both ends, as shown in the second picture. Feel the bare wire before you press down the switch. Now press down the switch. Put your finger near the bare wire, but do not touch it. It is growing hot!



Copper is not the only metal that becomes hot when it is conducting electricity. Iron also gets hot when it is used as a conductor. To show this, set up the circuit as shown at the bottom of the opposite page.



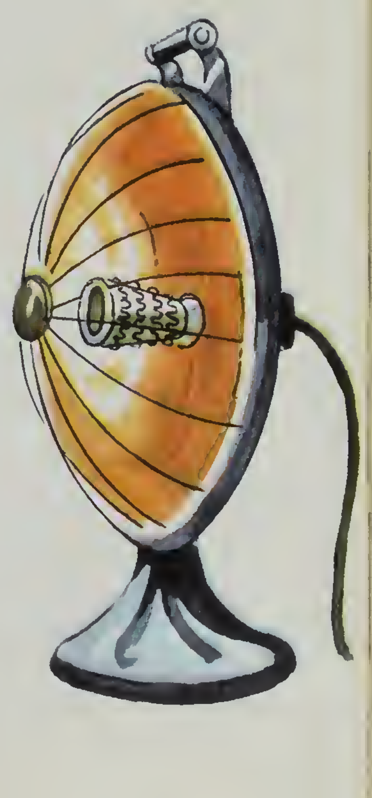
You will need to cut one copper wire into two pieces. Scrape the insulation from each end. Now twist together tightly an end of one of the pieces of copper wire and one end of the iron wire. Cover this connection with insulation tape. Do the same thing with the second piece of copper wire and the other end of the iron wire.




Press down the switch. Does the iron wire become hot? Be careful not to burn your finger. Try other kinds of metal in your circuit to find out if they are heated by electricity.

Sometimes we want electricity to heat wires in a heating pad or an electric blanket. Sometimes we want electricity to heat a special piece of metal, called a heating element, that is found in electric irons and electric toasters.

A heating element is made so that it can become very hot when electricity passes through it. This explains why the bread that is brought near the toaster element is toasted. The cloth that is brought near the heating element of an iron becomes hot. Trace the path of electricity through a toaster, an iron, and a heater.



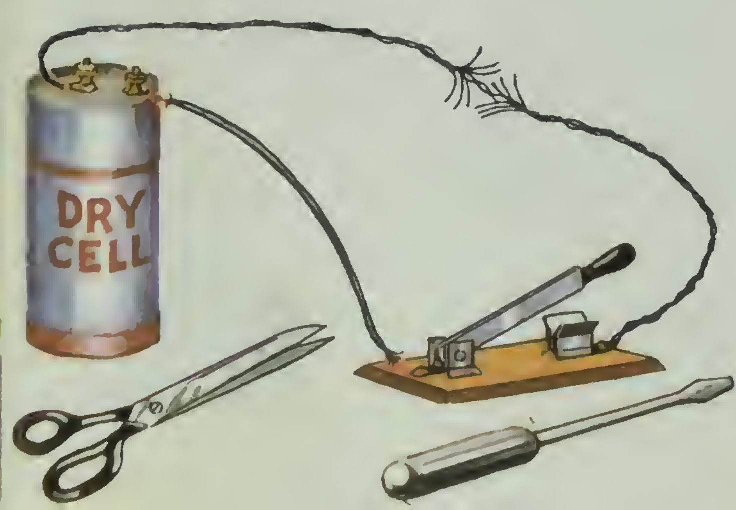
Because electricity produces heat, it is useful to us. But it can also be harmful. Insulation can wear off electric wires. Then, if the hot wires touch wood or cloth, the wood or cloth will burn. For this reason the electric wiring in a house, garage, school, or any other building should be checked from time to time to see that it is in good condition.

# Electricity Causes Light

Have you ever looked down inside a toaster? If you have, you have seen a dull-red glow after the toaster has been on for a while. This also happens to an electric heater. Electric heaters and toasters not only give off a great deal of heat, but also produce some light.

Electric irons, waffle irons, and sandwich grills can also grow so hot that they will produce light. But when this happens, they are much too hot to use and should be turned off at once.

Here are experiments that will help you to understand why some wires give off heat and no light, and why some produce heat and light: You will need two dry cells, a switch, two pieces of insulated copper wire, a screw-driver, scissors, and a piece of iron picture wire. The iron wire should be made of eight strands twisted together.



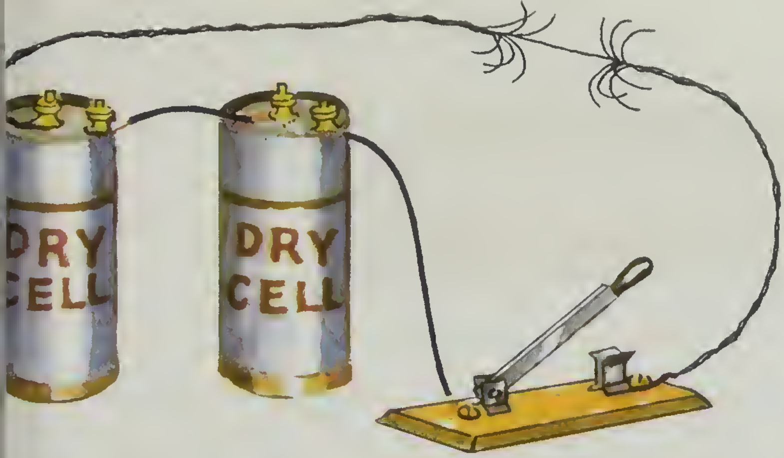

For the first experiment use only one of your dry cells and one of the pieces of insulated copper wire. Connect the insulated copper wire from the dry cell to one screw on the switch. Connect the iron picture wire from the other screw on the switch to the dry cell.

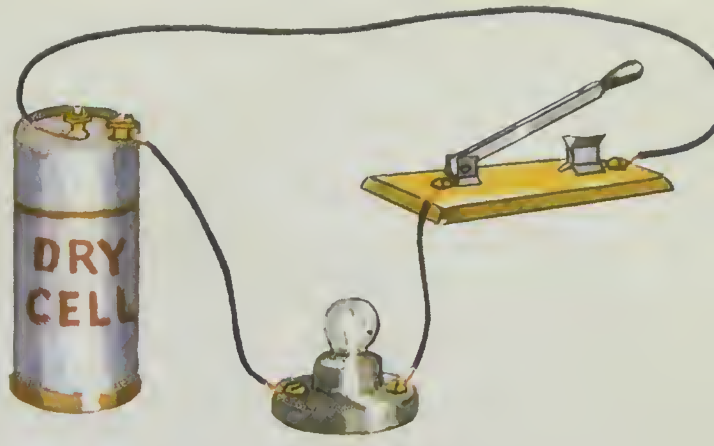
Now press down the switch. Hold your hand near the iron wire. Do you feel the heat? Next open the switch. Let the iron wire cool. Then cut through one strand of the twisted iron wire. Pull the cut ends apart so that they do not touch. Again press down the switch. Put your hand near the iron wire. Does it feel hotter?

Again open the switch. Then cut another strand of the iron wire. Press down the switch. Is the wire even hotter this time?

Keep doing this until there is only one strand of the iron wire left. It is quite hot now; so be careful!

Now you are ready for the second experiment. In this circuit you will need to use both dry cells. You will also use both pieces of insulated copper wire.






This circuit should look like the one on the left above. Darken the room. Then press down the switch. The iron picture wire is now so hot that it gives off light, as well as heat.

In these experiments you have done two things. You first made the path harder for the electricity to travel through by using less and less iron wire. This caused more and more heat to be produced.

Then you used more electricity by adding a second dry cell. If the path is hard enough and if there is enough electricity, light, as well as heat, is produced.

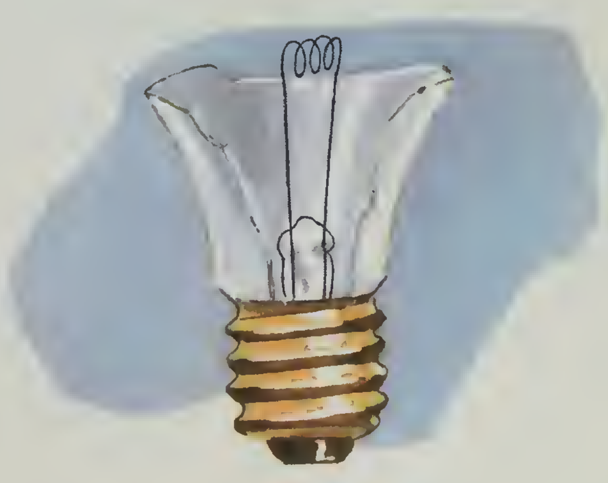
Now for another experiment. You will need a flashlight bulb and a small socket for the bulb, as well as one more piece of insulated copper wire. Put the bulb and socket in the circuit as is shown in the second picture above. The bulb gives off both light and heat.

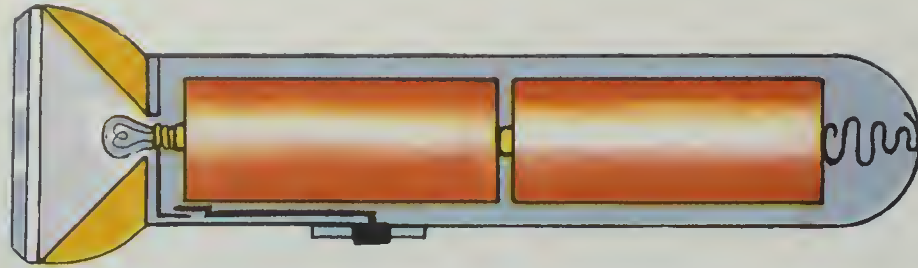
It would be interesting to see the thin wire inside a light bulb. So if you can find a burned-out light bulb, bring it to school.

Ask your teacher to help you to break the bulb. To do this, wrap the light bulb completely in newspaper. Use several layers of paper. Tap the bulb lightly with a hammer until it breaks. Unwrap the bulb.

Now you can see the thin wire in the light bulb quite clearly. Feel it. It is a very, very thin wire.

This wire is made of a metal called tungsten. Tungsten is a conductor of electricity. It can become very, very hot and not melt. For this reason tungsten is used to give us a bright, steady light.





## Tracing Electric Circuits

It is easy to trace the path of electricity from a dry cell through wires to a light bulb and then back to the dry cell. But it is not so easy to do this in a flashlight. One reason why it is difficult is that the flashlight does not use copper wire to conduct electricity.

Instead, the metal case of the flashlight may be used as part of the circuit. Or if the flashlight case is made of hard rubber, a strip of metal inside the case may be used to conduct electricity.

Bring a flashlight to school. Take it apart and study its parts carefully. Try to trace the path of electricity from the dry cells to the light bulb and back to the dry cells.

The drawing above may help you to understand how your flashlight is made. First, look at the dry cells. Flashlight dry cells look different from the large dry cells that you have been using.

Flashlight dry cells are smaller, of course. But there is also another important difference. A flashlight dry cell does not have two places on it for connecting wires. But if you examine it carefully, you will find a place where electricity can leave the dry cell and one where it can enter the dry cell.

Did you notice that the bottom of the flashlight dry cell has no paper covering? The bare bottom of the flashlight dry cell is really one connecting point. The other connecting point is the small metal cap at the top of the dry cell. Electricity enters and leaves at these points.

If the metal cap at the top of one of these dry cells is touched to the bottom of the other, a connection is made. This is the way the two cells are connected in the flashlight case. A spring in the bottom of the flashlight case helps to hold the two dry cells together tightly.

It is easy to see that the metal cap at the top of one dry cell touches the base of the light bulb. This is one connection to the bulb. The other connection to the bulb is the strip of metal around the base of the bulb. This strip is connected to the flashlight case.

You will notice that the bulb does not light until the switch on the case is moved. When this switch is moved, a complete circuit is formed. The electric path down the side of the case to the spring at the bottom of the case is completed.

Study the picture below to see how electricity runs a trolley bus.

The trolley wires form one part of the circuit. A double trolley pole reaches from the bus to the wires to complete the circuit.

Electricity is also used to run trolley cars, on tracks. In these a single trolley wire and pole form part of the circuit. The other part of the circuit is formed by the rails on which the car runs.

You do not get a shock by stepping on a trolley rail, because you have not completed a circuit. If you were so tall that you could stand on a rail and touch the trolley wire, then you would complete a circuit. But you would also be badly injured by too much electricity.

Some electric trains have double wires. One of the two overhead wires takes the place of the trolley-car rails.

# Electricity Is Used to Send Messages

If we were making a list of the ways in which we use electricity, probably one of the first uses on our list would be "to send messages."

In olden days messages were sent from place to place by messenger or by drum or by smoke signals.

A messenger would carry the news by word of mouth or in writing. Of course we still send messages in this way when we write letters, or when we ask one friend to tell another friend "Hello" for us. These are good ways to send messages, but sometimes they are too slow.

Messages may be sent very quickly by making use of electricity. One of the first means of sending messages in this way was the telegraph. You can send messages if you have a telegraph key, a telegraph sounder, some wire, and some dry cells. A simple telegraph may be set up as shown in this picture.

The sender of the message presses the telegraph key down. When he does this, a sound is made at the telegraph sounder. The sound is made because an electromagnet attracts an iron bar and causes it to move. When the key is released, the iron bar springs up again, and another sound is made.

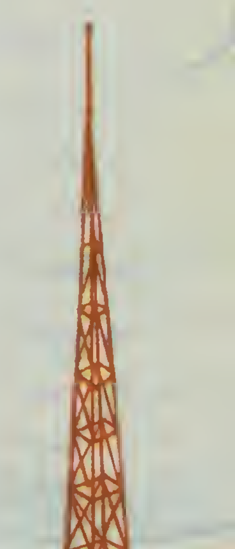
The key may be held down a short or a long time. Holding the key down a short time means there is only a short wait between the two sounds. Two sounds with only a short wait between them are called a dot.

Holding the key down a little longer causes a sound called a dash. When there is a dash, there is a longer wait between the two sounds. Dots, dashes, and combinations of these represent letters of the alphabet.

Electricity is used to send messages by telephone. There is a complete electric circuit between the telephone transmitter and the telephone receiver.

Radio messages are also sent by electricity. But radio circuits are different from both telephone and telegraph circuits. Have you ever noticed that there is no direct electrical connection between the radio station and your radio set? You may think there is because the radio in your house is connected with electricity in the house circuit.

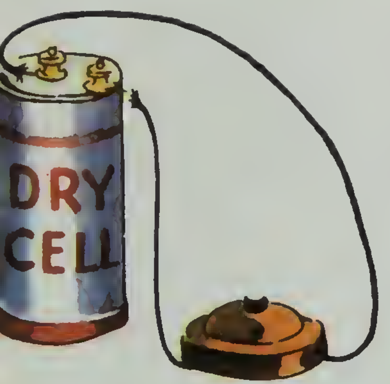
But think of the radio in your automobile. Think of a portable radio. These radios are not connected directly to the radio station. But they do use electricity from a battery to pick up radio waves.



At the radio station electric circuits produce radio waves which travel out into space. If these radio waves are strong enough, they will affect the electric current in your receiving set. Then this current makes the loudspeaker work, and you can hear music and words coming from your radio.

Isn't it wonderful that we have learned to send messages by means of electricity?

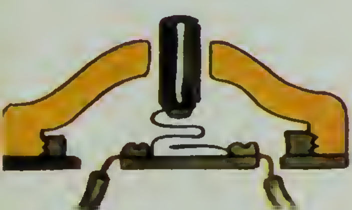
# Doorbells Use Electricity




Some kindergarten children built a house of blocks. It was a large house, large enough for a table, two chairs, and a doll's bed. The children used it when playing house. They had a play telephone in the house. They had dishes and a small stove. But they had no bell for the front door.

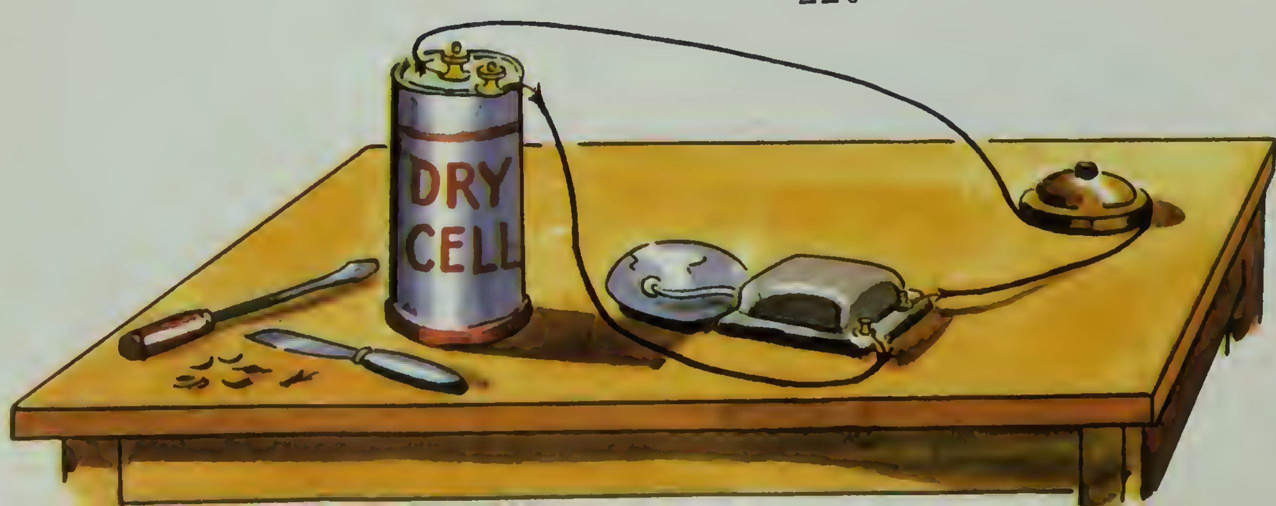
They asked their teacher if they might have a real doorbell. She said that they might and that she would get the materials. When she showed the dry cell, switch, wire, and bell to the kindergarten children, one of them said that her older sister, in another class, had been working with dry cells. The kindergarten children decided to ask the older children to help them with wiring their doorbell.

All the materials were taken to the older children so that they could try out the materials and make plans for the wiring. The first picture on this page shows the first circuit that they made. They pressed and pressed on the black button, but no sound was heard.



They checked all the connections carefully, but still they heard no sound. Study the first circuit and see if you can discover what the trouble was. Of course! There was no bell in the circuit. The older children had thought the push-button switch was the bell.





No wonder they thought the switch was a bell! Many times they had said to each other, "Let's push the bell by the door to see if they're home." The children should have said, "Let's push the switch."

When the children examined the push-button switch carefully, they found that this switch had two places for connecting wires. Every switch must have connecting places for two wires.

Look at the second picture on the opposite page. It shows the inside of a push-button switch. When the button is pressed down, a connection is made between the two pieces of metal.

Then the children made a circuit like the one you see at the bottom of the opposite page. In this circuit they used a dry cell, a push-button switch, a bell, and some insulated copper wire.

All the connections were carefully made. All the screws were tightened. Just enough insulation was scraped off the ends of each piece of wire to make a proper connection.

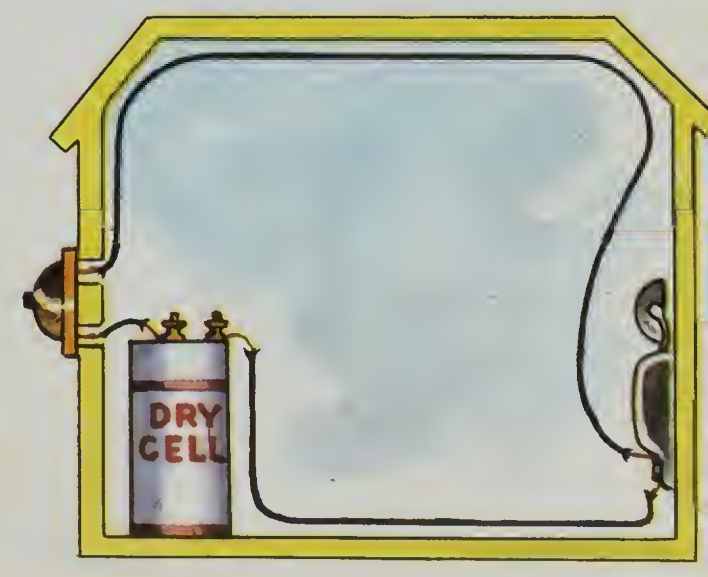
Then they pressed down on the push-button switch. There was a loud noise. The bell was ringing!

The older children were then ready to wire the bell for the house; so they drew a plan. It looked something like the plan below.

The push-button switch was placed outside the front door. The dry cell was placed in one corner of the room. The bell was placed at the back of the house on the wall.

Because the bell was placed at the back of the house, two long pieces of insulated wire were needed. A shorter piece was needed to go from the dry cell to the switch. The distances were measured carefully so that the right amount of wire could be cut. Several older children did the wiring. They were careful to tighten all connections.

When they had finished, all the kindergarten children gathered round. One of them pressed the push-button switch. The bell rang. How pleased they were!



# Wiring a Barn for Lights

Now the kindergarten had another job for the older children. The kindergarten children had a barn in which they put their toy animals. They decided that they would like very much to have the barn lighted.

They decided that they would like two lights in their barn. They also decided that the switch should be on the wall outside the barn.

Again the kindergarten teacher got the materials together. Several of the children took the materials to the older children's room. They took two dry cells, two light bulbs, two sockets for the light bulbs, a switch, and insulated copper wire.

Then the older children were ready to experiment with these materials. First, they made a circuit with one light bulb and socket, the switch, and one dry cell. When the switch was pressed down, the little light burned brightly.

Then they made a circuit with two bulbs and sockets. Their circuit looked like the one on this page.

Again they pressed the switch. The lights burned very dimly. How disappointed they were!

Then one child asked, "Why don't we use two dry cells if we want two lights?" When they put the second dry cell in the circuit, they were careful to connect a wire from the middle screw of one dry cell to the outside screw of the other.

Then the switch was pressed. Each small light burned brightly.

Then someone asked, "If the kindergarten children should want only one light to burn, what would they do?" Someone else said, "They would need to unscrew one light."

The older children tried this. Just as soon as the first light was unscrewed, the second light went off. They found that neither light would burn unless both were screwed in tightly.

Certainly this would never do. When the older children asked their teacher for advice, she said she would be glad to help. In her circuit she used one dry cell, two bulbs and sockets, the switch, and wire. But her circuit looked quite different from the other circuits.


The teacher's circuit looked like this one. Notice how the wiring differs from the children's circuit. One of the children pressed down the switch. At once everyone noticed that this was a better circuit. Each of the lights burned brightly. Still this circuit used only one dry cell. What a difference the teacher's way of wiring made!

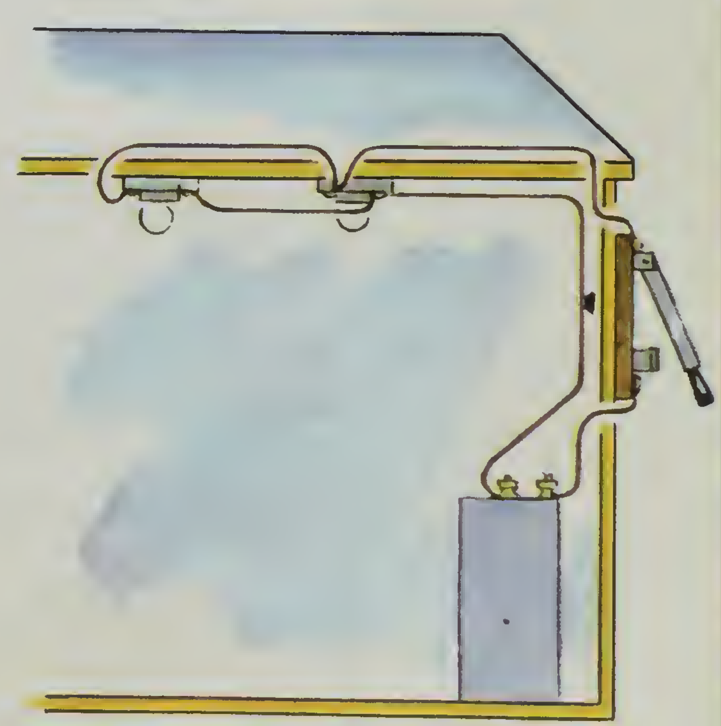
Would you be able to unscrew one of the light bulbs and still have the other light burn? The children tried to do this. One light bulb was unscrewed, and the other light still burned. Then they screwed the light in again and unscrewed the other bulb. One light still burned!

At last they had the proper circuit. This circuit used only one dry cell, and yet both lights burned brightly. Both lights could be turned on by the switch. Either bulb could be unscrewed, and the other would burn.

Now the older children made their plan for lighting the barn. It looked something like the one below.

They took the plan and materials and worked in the kindergarten room. They were careful to make all connections tight. This was especially hard at the socket connections because two wires are placed at each of these connections.

At last the circuit was completed. What fun it was when the lights burned!



1. People have only been certain that lightning is electricity for about two hundred years. The man who made this discovery was Benjamin Franklin. Franklin believed that if lightning was really electricity, it would travel down a wet string.

The only way he could think of to get the wet string up into the air was to tie it to a kite. This he did when the next storm came. He let the end of the kite string touch the top of the kind of jar that could capture electricity. During the thunderstorm, some electricity passed down the kite string and was stored in the jar. Franklin proved that lightning is really electricity!

But you should not try to do this experiment, for it is a very dangerous one. You might be badly hurt by the lightning.

2. If you are interested in magnets and have not done much work with them, perhaps you would like to find out more about them. Each magnet has a north-seeking pole, or end, and each has a south-seeking pole, or end. Find out what happens when the north-seeking ends of two magnets are brought together. What happens when a north-seeking end of one magnet is brought near a south-seeking end of another magnet?



3. Electric bells, electric clocks, telephone receivers, and electric motors work because each contains an electromagnet. Find out how to make an electromagnet; then make one.

4. Set up an electric circuit so that you can test materials to see whether or not they are good conductors of electricity.

For such a circuit you will need a dry cell and some wire. You will also need a bell or a light bulb and socket so that you will know if electricity is in your circuit. Test as many different kinds of materials as you can to see if each is a good or a poor conductor.

5. Ask the custodian of your school to help you trace the circuit of the electric-bell system in your school.

6. Set up an electric-bell system from one room in your home to another room. The switch might be near the telephone, and the bell might be in the basement, so that a person at work there could be called to the telephone.

Let's think of the materials you will need for this.

You will need insulated copper wire, a switch, a bell, and a dry cell.

Be sure to use a dry cell and not the electricity in your house circuit. Never work with the house circuit or school circuit unless an adult is there to help you.

7. Ask the principal of your school if you may look at the blueprints showing the wiring of your school. By studying the blueprints, see if you can find where the electricity enters your building and how it gets to your room.

Take good care of these blueprints. They must be used when wiring is repaired. What careful wiring plans an electrician must make for a building!

8. Make a list of all the ways that electricity is used in your home. Now pretend that you are living two hundred years ago. Describe what your home would be like without any electricity.

9. Does your community use power from coal or water to run its electric generator? Arrange a trip to the generating station. Try to find out how electricity is produced by the generators.

# Animals Live Together

# Listening to Animal Sounds

Did you ever lie quietly somewhere in a woodsy place near a stream, just listening? If you closed your eyes, perhaps you heard sounds more clearly. There was the buzz-buzz of bees. There was the splish-splash of the fish. There was the cawing of crows.

Perhaps you even heard the soft hop of a rabbit or the croak of a frog. Surely you heard the song of that sparrow! Sh-h-h-h, was that the whir-r-r of a grasshopper as he flew away?

If you were near a beach, it may have been the cry of the gulls or the sandpipers that you heard. Or if you were on a prairie at night, perhaps it was the call of the coyote or the far-off moo-o-o of a cow.

Many different kinds of animals live near us. If we listen, we can hear the sounds of animals all around us.



## Many Kinds of Animals Live in a Community

Some children in Ontario decided that they would make an animal map of a farm near their school. So they visited the farm.

All the children climbed up into the loft of the barn in order to look out over the land. With the farmer's help they made a map of the farm.

Next they divided into groups. Each group visited a certain part of the farm to see how many different animals lived there. One group stayed near the house and the barn. This is their list:

| | |
|---|---|
| pigeons | pet canary |
| cows | flies |
| horses | cats |
| dogs | mice |

Another group visited the pastures not far from the house. Here is their list:

| | |
|---|---|
| cows | butterflies |
| pigs | birds |
| grasshoppers | bees |
| worms | wasps |

A third group walked along the banks of the stream. Here is their list of animals:

| | |
|---|---|
| fish | water bugs |
| frog | snake |
| turtle | dragonflies |

The fourth group went into the woods. Here is their list:

| | |
|---|---|
| birds | chipmunk |
| squirrels | bees |
| rabbit | caterpillars |
| salamander | spiders |

The children drew pictures of these animals in their proper places on the map. They never thought that so many different kinds of animals lived together in a farm community.

One reason these animals live here is that they find enough food, enough shelter, enough water, and enough warmth. Many of them are well protected from their enemies. There are no wolves on the farm to destroy the cattle. The farmer does not allow hunting on his land; so the birds are well protected, too.

Of course, not all the animals have always lived on this piece of land in Ontario. What animals do you think lived there long ago?

When this land was forest area many years ago, there were no horses, cows, pigeons, or pigs. These are domesticated animals. They were brought by men to this farm land.

Forest animals, such as foxes, raccoons, and wildcats, lived here once. Now there is no longer a place for these animals in this farm community.

Another group of children made a picture of a city street to show the animals that lived or visited there each day.

Not nearly so many different kinds of animals live in the city streets. This is not a good place for most animals to live. We would find more animals in the park, where they find better food and shelter.

# Some Animals Live Alone in the Community

All the animals on these pages may live in the same community, but they do not live together in family groups. Some of them—for example, the frogs—live near water, but they do not live and work together. None of the animals in the picture live together in a home. Each of them finds its own food.

At times during the year these animals come together to mate. Then some of them may live together in pairs for a short time. But after the young are able to find their own food, the family group breaks up.

Sometimes you may see several frogs sunning themselves on a log or rock or on lily pads. It may seem that these frogs are living together in a family group. But this is not true. They are together only because this happens to be a nice, sunny place to be. Each one found this place by itself. Each one crawled up on the rock. Each one leaves when it is ready to leave.



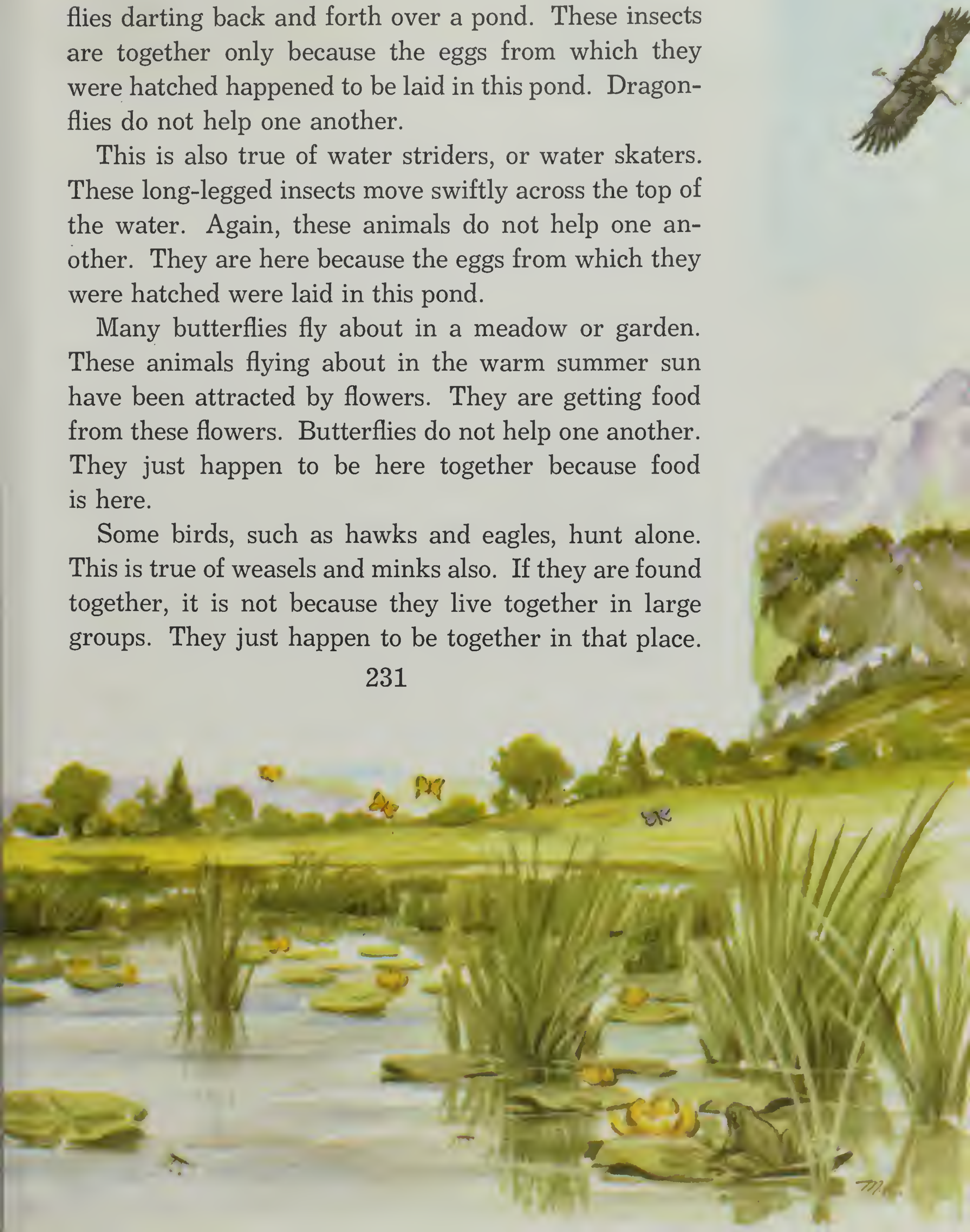
In the spring and summer you may have seen dragonflies darting back and forth over a pond. These insects are together only because the eggs from which they were hatched happened to be laid in this pond. Dragonflies do not help one another.

This is also true of water striders, or water skaters. These long-legged insects move swiftly across the top of the water. Again, these animals do not help one another. They are here because the eggs from which they were hatched were laid in this pond.

Many butterflies fly about in a meadow or garden. These animals flying about in the warm summer sun have been attracted by flowers. They are getting food from these flowers. Butterflies do not help one another. They just happen to be here together because food is here.

Some birds, such as hawks and eagles, hunt alone. This is true of weasels and minks also. If they are found together, it is not because they live together in large groups. They just happen to be together in that place.







Spiders usually live alone. Those that spin webs do their spinning alone. The spider that did the spinning uses the web alone.

The triangle spider is a very common spider. It gets its name from the shape of its web. Because the four main threads are fastened together at one end, the web looks very much like a triangle. Insects are caught on the sticky cross threads of the web. The spider does not share this food with other spiders. Triangle spiders live alone.

Trap-door spiders also live alone. They build a nest by digging a hole in the ground and lining the hole with a liquid from the body. When the liquid hardens, it forms a tough, paperlike material. The spider makes a door to its nest and fastens it at one side. It is difficult to open the door to the spider's nest.

The female trap-door spider lays its eggs in this hole. After the young trap-door spiders are hatched, they live in the nest with the mother spider for about eight months. When the young trap-door spiders leave the nest, the mother spider lives alone again.

Mason bees are also insects that live alone. They may build their nests under stones or logs. Sometimes they even build them in empty snail shells.

The nest is made of sand and clay put together with a sticky liquid which comes from the mother bee's body. Several cells are built in each nest. The mother bee puts a little food in each cell for the young bee.


Carpenter bee

Potter wasp

The female mason bee lays an egg in each cell. After this the bee puts a thick cover over the top of the nest to protect the eggs. This cover is made of the same material as the nest. The bee then flies away and leaves the eggs to hatch.

The female leaf-cutting bee digs round holes in the ground, in wood, or in hollow stems. Each hole is lined with small pieces of the petals and leaves of plants. The bee lays an egg in each nest. Then several pieces of leaves or petals are pressed down on top of each nest. These form a tightly fitting cover. Now the leaf-cutting bee flies away and leaves the eggs to hatch.

Carpenter bees are about as large as bumblebees. A female carpenter bee will build a tunnel in a fence post for her eggs.

A female mud dauber is a wasp that builds a nest of many cells. These nests are found under window ledges, eaves of houses, bridges, and other places. Each tube-shaped cell contains a spider, which will be used as food by the young wasp.

A female potter wasp builds her nest on such plants as blackberry and raspberry bushes. Each cell in the nest has an egg in it. There is also a caterpillar in each cell. The caterpillar will be used for food by the young wasp.

The cicada-killer is a wasp that lives alone, too. The female builds a nest in the ground. The wasp puts cicadas in the nest for the young to use as food after they hatch from the eggs.



Mud dauber

Cicada-killer

## Some Animals Live in Groups

One of the familiar animals of the Great Plains of North America is the prairie dog. Prairie dogs are not really dogs. They belong to the same group of animals as squirrels.

These animals live in communities, or colonies. Some colonies have only forty or fifty prairie dogs. Others have a thousand or more.

A prairie-dog community is made up of underground tunnels. Some tunnels are as much as 14 feet long. Measure out 14 feet on your classroom floor so that you can see how long one of these tunnels would be.

At the entrance of each tunnel is a little mound of earth. In each tunnel are large holes. These holes are used for sleeping and as nests for the young prairie dogs.

Prairie dogs are destructive animals because they feed on almost all the plant life near their holes. They eat the leaves, roots, stems, and fruits of plants.

Several prairie dogs always keep watch for the group. They sit on the mounds of earth at the tunnel entrances.

These prairie dogs warn the colony when an enemy comes near. Then they all scamper into their burrows. Prairie dogs protect each other by living in groups.



Some birds live in groups. Pelicans usually do. These birds are fish-eaters. The pelican has a queer pouch, which hangs from its lower bill. This pouch is used as a scoop for catching fish. It may be as much as 18 inches long and 6 inches deep.

It is interesting to watch a group of pelicans work together catching fish. They swim out from shore quite a distance. Then they form a long, curved line and swim toward the shore.

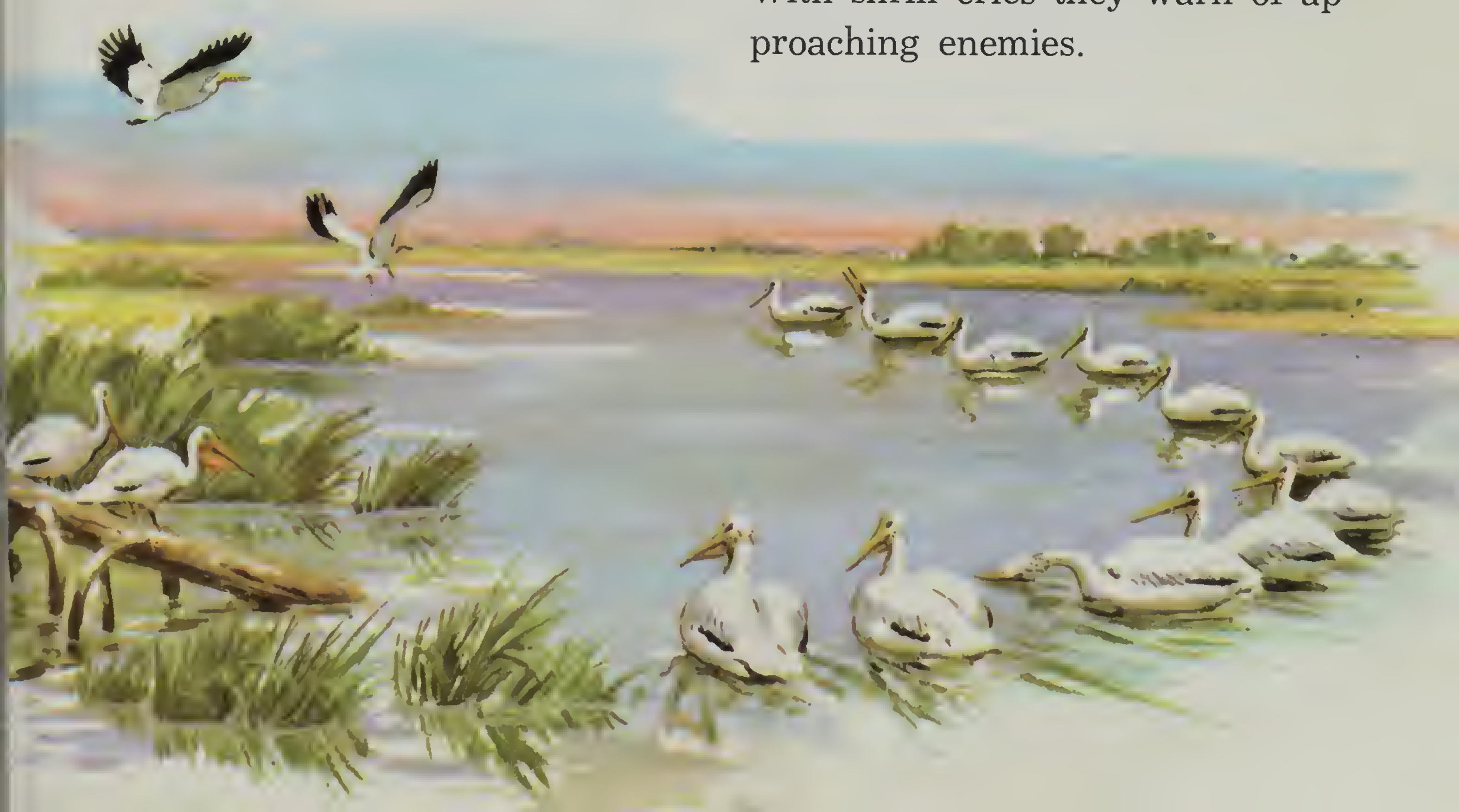
As the pelicans swim, they drive the fish before them. Soon there are many fish together in a fairly small space. Then it is much easier for the pelicans to scoop up the fish and eat them.

Insect-eating birds, such as swallows, also band together in groups. These birds fly about together hunting insects. If one bird misses an insect, another usually catches it.

Groups of gulls are often found together also. Sometimes fishermen watch gulls to see where they are feeding. Then they select that spot as a good place to fish.

Gulls dive toward the water to catch fish which they see swimming about. They also eat clams. A gull will pick up a clam, fly up into the air with it, and drop it on the rocks below. Then the gull will swoop down and eat the clam from the broken shell.

Gulls nest near one another on rocky islands not far from shore. With shrill cries they warn of approaching enemies.



Have you ever watched a group of fish swimming about in a stream or pond? A group of water animals moving about together is called a school. If an insect or smaller fish escapes one of the fish in the school, another is usually able to catch it.

Some ocean fish also travel in schools. Cod and mackerel form schools. When fishermen find a school of these fish, they can often fish for hours because the school is so large.

Other ocean animals, such as whales and porpoises, often travel in schools. It is great fun to watch a school of porpoises following a ship. They leap out of the water again and again as they swim along waiting for food to be thrown to them from the ship.

Shrimps swim about in schools, hunting for food. Along the coast of Mexico a good time to catch shrimps is the late afternoon or early evening.

Then hundreds of shrimps swim toward the shore. Fishermen go out in rowboats to catch them. They stand up in the boats and throw out large, round nets. The shrimps, swimming near the surface of the water, are caught in these nets.

Hundreds of oysters are found living near one another in certain places. They are able to live in these places because the temperature of the water is right for them and because there is enough food. The place where there are many oysters living together is called an oyster bed.




All animals need the right kind of food if they are to live. This is true of oysters. These animals feed on tiny plants and animals.

Oysters do not move about hunting for these plants and animals. They wait for their food to float by in the water. If there is not enough food in a place, the oysters die out. If there is the right kind of food and the right water temperature, hundreds and hundreds of oysters may live near one another.

Where oysters are found, two other animals are often found also. And they are often found in great numbers. These are the enemies of the oysters.

Some kinds of starfish are enemies of oysters, since they use oysters for food. From time to time entire oyster beds have been destroyed by starfish.

Oyster drills are enemies, too. These animals are a kind of sea snail. An oyster drill makes a hole in the shell of an oyster and feeds on the oyster through the hole.

You can easily see why hundreds of oyster drills may live together in or near an oyster bed. They find food easily there.

Coral polyps are also animals that live near one another. They seem to do this for much the same reasons as oysters. If there are the right kind of food and the right temperature, many coral polyps are found together.

Each of these tiny animals builds a hard cup around itself. When a coral polyp dies, another coral polyp attaches itself to the old cup and begins to build a new cup. After many years millions of these hard cups may be formed in one place in the ocean. They are called coral reefs and islands.

## Herds of Animals

Some animals stay with one another as they move from place to place. This is often true of the grazing animals, such as cows, sheep, deer, and goats. A group of such animals is known as a herd.

Most herds of animals are led by a male. But an old female elephant usually leads a herd of elephants.

After the mating season some deer form male and female herds. One leader would be a male. He would lead the males. The other leader would be a female, and she would lead the females.

Animals may become leaders of their herds by fighting. The winner of the fight will be leader so long as he is strong enough to win fights. A leader must fight many, many times to continue to be leader of the herd. No weak animal is leader very long.

You probably have thought of one reason why it is good that some animals live in herds. Animals living in herds are better protected from their enemies. One animal alone might not be able to kill an enemy, but a herd could.

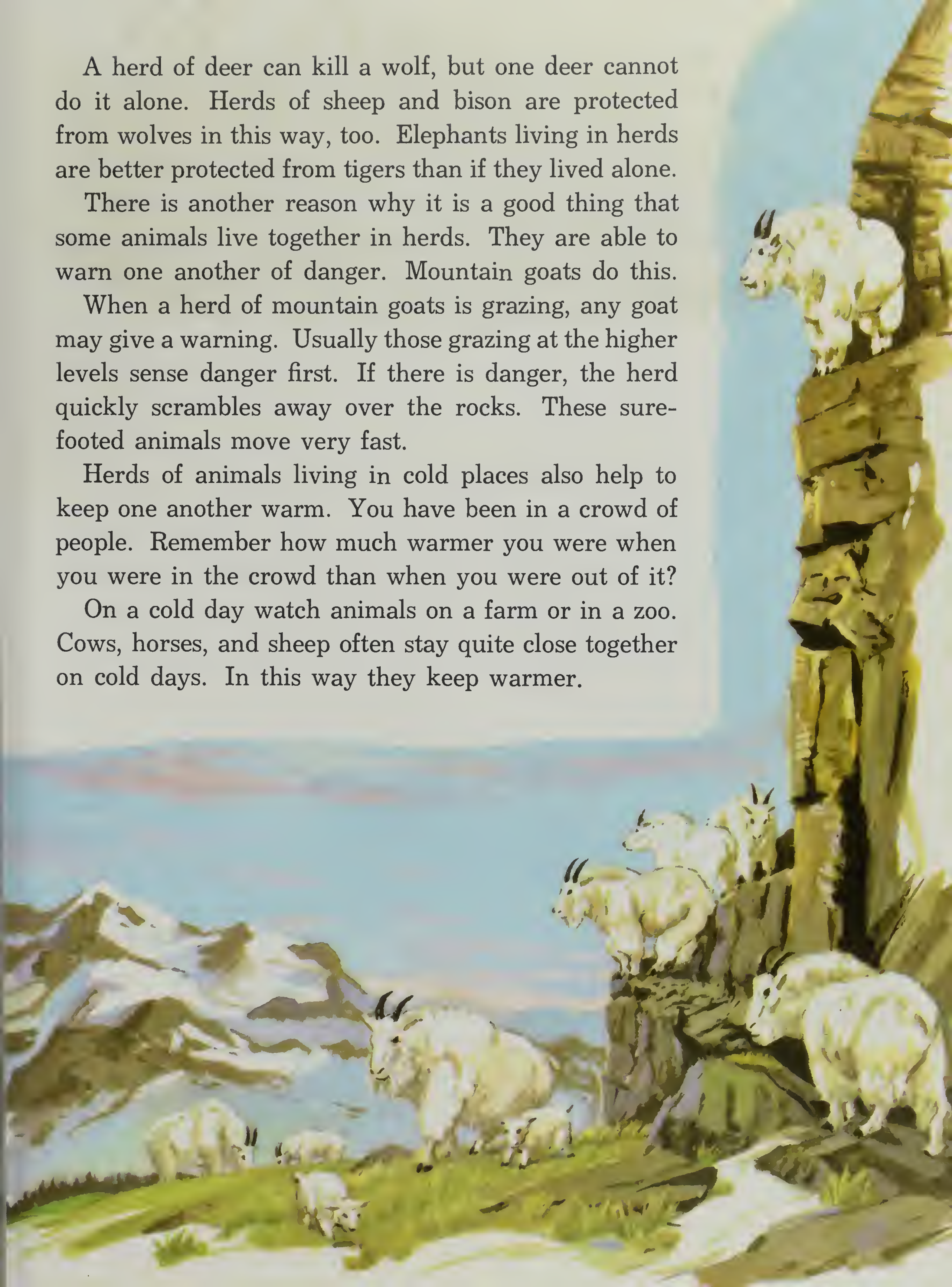
A herd of deer can kill a wolf, but one deer cannot do it alone. Herds of sheep and bison are protected from wolves in this way, too. Elephants living in herds are better protected from tigers than if they lived alone.

There is another reason why it is a good thing that some animals live together in herds. They are able to warn one another of danger. Mountain goats do this.

When a herd of mountain goats is grazing, any goat may give a warning. Usually those grazing at the higher levels sense danger first. If there is danger, the herd quickly scrambles away over the rocks. These sure-footed animals move very fast.

Herds of animals living in cold places also help to keep one another warm. You have been in a crowd of people. Remember how much warmer you were when you were in the crowd than when you were out of it?

On a cold day watch animals on a farm or in a zoo. Cows, horses, and sheep often stay quite close together on cold days. In this way they keep warmer.



Partridges sleep together

## Together for Sleeping and Eating

Have you ever visited a large chicken farm, or perhaps raised chickens yourself? If you have done either of these things, you have surely noticed how chickens scatter about during the day.

But when night comes, these animals band together. They roost very close together.

This is a good thing. If one chicken is attacked by an enemy, its cry wakens all the others because they are so near.

Other birds, such as turkeys, also come together at night for protection. If an enemy is near, a turkey will cry out. Then the other turkeys have a chance to get away.

Weasels, foxes, and other enemies hunt chickens and turkeys at night. A cry often saves a whole flock.

Partridges band together for sleeping also. These birds sleep in a circle with their heads pointing out. In this way they are better able to hear sounds made by an enemy.

Many other birds roost together in trees or buildings for the night. If you are a good observer, perhaps you have seen a flock of birds settling down together in a tree for the night.

Some animals band together to get food more easily. Some of these animals are the meat-eating, hunting animals.

Wolves may hunt for food together. Often they divide into two packs. One group chases the animals that will be used as food. The other group blocks the path of these animals, so that they are more easily killed.

Sometimes all the members of a lion family will hunt together. Some of the lions go through the brush. This scares out animals. Then the other lions jump upon the hunted animals as they run past.

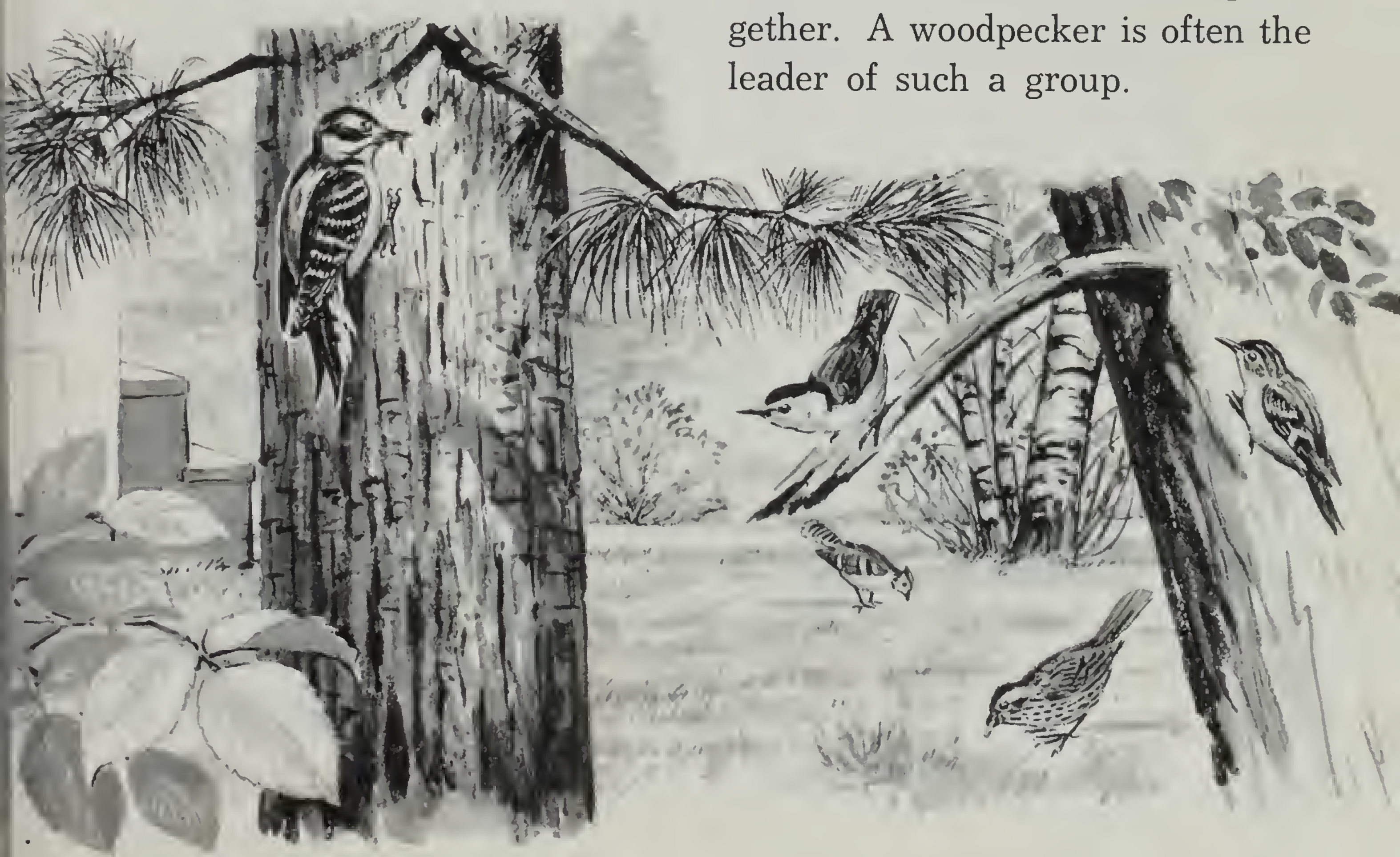
Not all animals that band together for feeding are hunters of other animals. Some animals seem to feed together just because food is there.

Elk, antelope, and cows are often seen feeding together in a feeding herd. As night comes, these animals may go by themselves again.

Some kinds of birds feed together. Have you noticed robins together on a lawn? They are probably feeding together just because there are a good many earthworms for them to eat.

In the city streets pigeons come together to feed. Day after day they come to the same places because they have become used to finding food there.

Sometimes different kinds of birds feed together. In the group there may be nuthatches, creepers, and woodpeckers, all feeding together. A woodpecker is often the leader of such a group.



## Some Birds Migrate Together

Ducks or geese flying in a V formation are beautiful. Have you watched them flying in this way? Perhaps you were close enough to a quiet pond to watch them swoop down from the sky. They settle down with much noisy chatter.

At some times of the year there are many more wild ducks and geese in a community than at other times. Ducks band together in the spring and fall for migration. Geese also band together for migration.

These birds migrate north for the summer. Here they lay and hatch their eggs.

In the fall ducks migrate south. This is also true of geese. The young ducks and geese are strong enough to fly with the older ones. In the southern United States they find plenty of food.

Many other kinds of birds flock together in the fall to migrate. As the days get colder and colder, you will see fewer and fewer birds. This is because the flocks of birds are on the way to their winter homes.

In the spring the flocks return. Some birds will stay in your community. Others will pass through on their way north.

The spring bird migration is often more interesting to watch than the fall migration. This is because many birds are so beautifully colored in the spring of the year.

As fall comes, the colors of many birds change. Sometimes the change in color is so great that you might not know them as the same birds.

If you are interested in birds, you might like to discover the ones that migrate to and from your community during the year.

To do this, you will need to learn to know some of the more common kinds of birds around you. Learn to know five to ten kinds of the common wild birds.

Then keep a record of the kinds of birds you see during the different months of the year. During some months you will see many of a certain kind of bird. Find out what happens to these birds during the months when they are not commonly seen in your community.

## Some Fish Migrate

Eels are among the most interesting of our migrating fish. They are the only fish we know about that migrate down the rivers to the ocean to lay their eggs.

The eggs are laid in such warm ocean waters as those of the Caribbean. Here the eggs stay until they hatch into young eels.

Eels which are about a year old look very little like their parents. They are not more than 3 inches long, and you can see right through them.

At this time in their lives they begin to migrate. They journey toward rivers to the north. The long journey takes about a year.

Up and up the rivers the eels swim. Here they spend eight or more years. Then the adult eels migrate to the Caribbean. Here eggs are laid and hatched. The young eels stay here until they migrate.

Salmon also migrate, but they migrate *up* rivers to lay their eggs. The salmon of the Pacific Ocean migrate in the summer or fall. These salmon swim up such rivers as the Columbia, the Fraser, and the Skeena to lay their eggs.

Salmon of the Atlantic Ocean migrate in the spring and early summer. Many of the Atlantic salmon swim up such rivers as the St. John and the Restigouche.

In the spring one of the interesting sights along the rivers of the Atlantic coast is fishermen preparing for the running of the American shad. Shad are fish, and so they do not really run. But when these fish are migrating, fishermen say the shad are running.

Fishermen put up poles in the rivers and fasten nets from pole to pole. In these nets many shad are caught. The picture above shows how the poles which hold the nets are placed.

Fishermen like to catch shad because they are good to eat. The best time to get fresh shad is during the spring migrating time.

Many other kinds of fish also migrate. They migrate to lay their eggs, to get to warmer water, or perhaps to find a better food supply.

Fishermen know the ways of fish. They wait for the migration time so that they may catch these fish for food or for oil. A kind of herring called the mossbunker is caught because its body contains much oil.

Mossbunkers are easy to catch, since so many of them migrate together. Some years millions and millions of mossbunkers travel together in one school.

Cod, mackerel, butterfish, sea bass, porgy, and whiting migrate, too. If you live in a coastal state, perhaps you know several other fish that migrate.

## Some Mammals Migrate

Fur seals spend most of the year in the warmer waters of the Pacific Ocean. But as warmer weather comes, they migrate north.

These animals go to the Pribilof Islands. Find the Pribilof Islands on a map. They are off the coast of Alaska, to the northwest of the Aleutian Islands. Here the young seals are born. In the fall young and old seals migrate.

Whales also band together and migrate to places where their young are born. The adult whales travel far out into the ocean. They stay together until young whales are born. The young whales are cared for until they are old enough to get food for themselves.

# Bees Are Social Animals

"You're as busy as a bee!" Has your mother ever said this to you? Surely most bees appear to be busy.

They buzz and buzz as they fly from one flower to the next. When they have enough nectar, they fly back to their hives. Here they go to work filling up wax cells with the nectar they have gathered.

What a busy, busy place a beehive is!

Honeybees are very social animals. Let's see how so many thousands of bees can live together in such a large family.

In the hive are three kinds of honeybees. There is one bee that is larger than any other in the hive. This is the queen bee.

There are some drone bees. Then there are thousands of smaller bees, which are the worker bees.

There is only one mother bee for each hive of bees. She is the queen bee, the largest bee in the hive.

A queen bee is fed on "royal jelly." This is a special honey food. Worker bees always guard the queen. She is very important, since she lays all the eggs.

A queen bee mates once during her lifetime. When she leaves the hive to fly high into the air, many drone bees follow her.

Drone bees are father bees. Only one drone bee mates with the queen. Then the queen bee flies back to her hive. Soon she begins to lay eggs.

A queen bee will sometimes lay more than a thousand eggs in one day. Most of the eggs will hatch into worker bees. Some eggs will hatch into drone bees. A few eggs will hatch into queen bees.

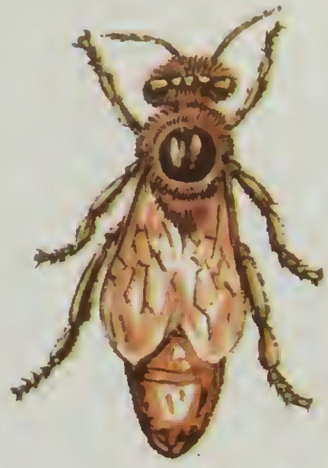
In a beehive are thousands of cells made of wax. Each small cell is something like a six-sided room. These cells have been made of wax by the worker bees.

In order to make wax, the workers eat a great deal of nectar. Then they crawl to the top of the hive. Here they hang themselves upside down. Soon wax begins to form on the underside of their bodies.

Other worker bees use this wax to make new cells. Cells are built at the top of the hive first. Some cells will be for eggs. Other cells will be storage places for honey.

Worker bees mend the hive with a sticky material which is gathered from the buds of trees. This sticky material is put into holes and cracks in the hive.

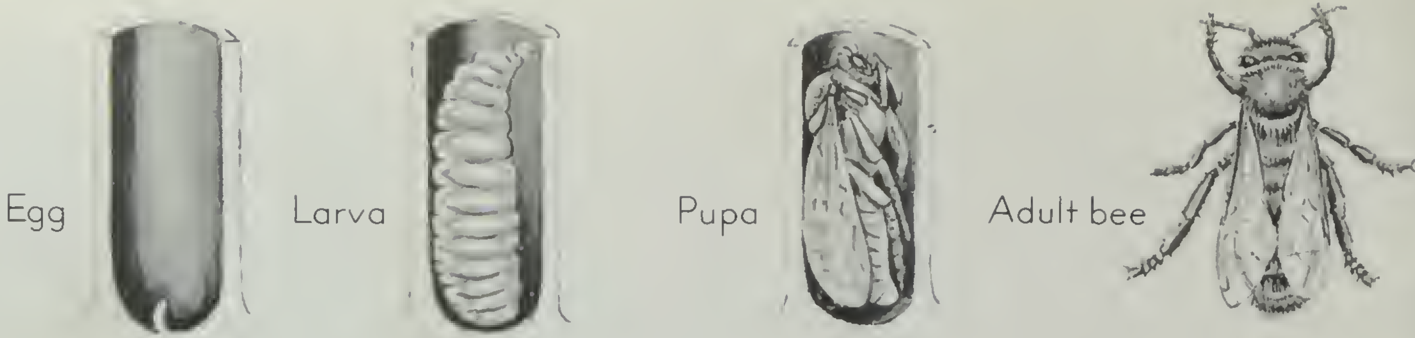
Queen bee



Drone bee

Worker bee

Rows and rows of wax cells are made. Many, many more bees are needed as the summer goes along. Thousands of wax cells must be made for the thousands of eggs that the queen will lay. Thousands of other wax cells must be made for the storage of honey.




Some worker bees fly from flower to flower, gathering nectar. The sweet nectar goes into the first of their two stomachs. This is the honey stomach.

When the honey stomach is full, back to the hive flies the worker bee. Then the bee stores the nectar in the wax cells.

Water must evaporate from the nectar if it is to turn into honey. As you know, fanning helps water to evaporate. Some of the worker bees fan and fan the nectar with their wings. This makes the water in the nectar evaporate faster and form honey.

Worker bees gather pollen too. Pollen sticks to the long hairs on a worker's body. Pollen also is carried in hollow places on the hind legs, called baskets.

When a worker reaches the hive, other workers help to unload its pollen. They put the pollen into wax cells, where it is mixed with nectar. This mixture is beebread.

Other workers are nurses. When the eggs hatch into larvae, workers feed the larvae. First, they feed them a milky-white liquid from their own bodies. Later the larvae are fed on beebread.

After a few days each larva changes into a pupa. Now the young bee rests. Now its body changes. About three weeks after an egg is placed in a cell, the full-grown bee eats its way out.

At first the bee is very weak. But in a day or two it is a strong, full-grown bee.

Some of the eggs laid by the queen hatch into drone, or male, bees. It takes about twenty-four days for these eggs to hatch. Drones are broader and larger than workers, but they are very helpless.

Drones cannot gather food. They cannot sting, because they have no stinger. You may think that drones are only lazy bees, but there is little that they are fitted to do.

What are drones good for, then? One of them will mate with the queen. If this did not happen, there would be no young bees. Soon the hive would be empty.

Drones live only one or two months. They all die in the fall, when they are no longer needed. The workers stop feeding them, and the drones starve to death.

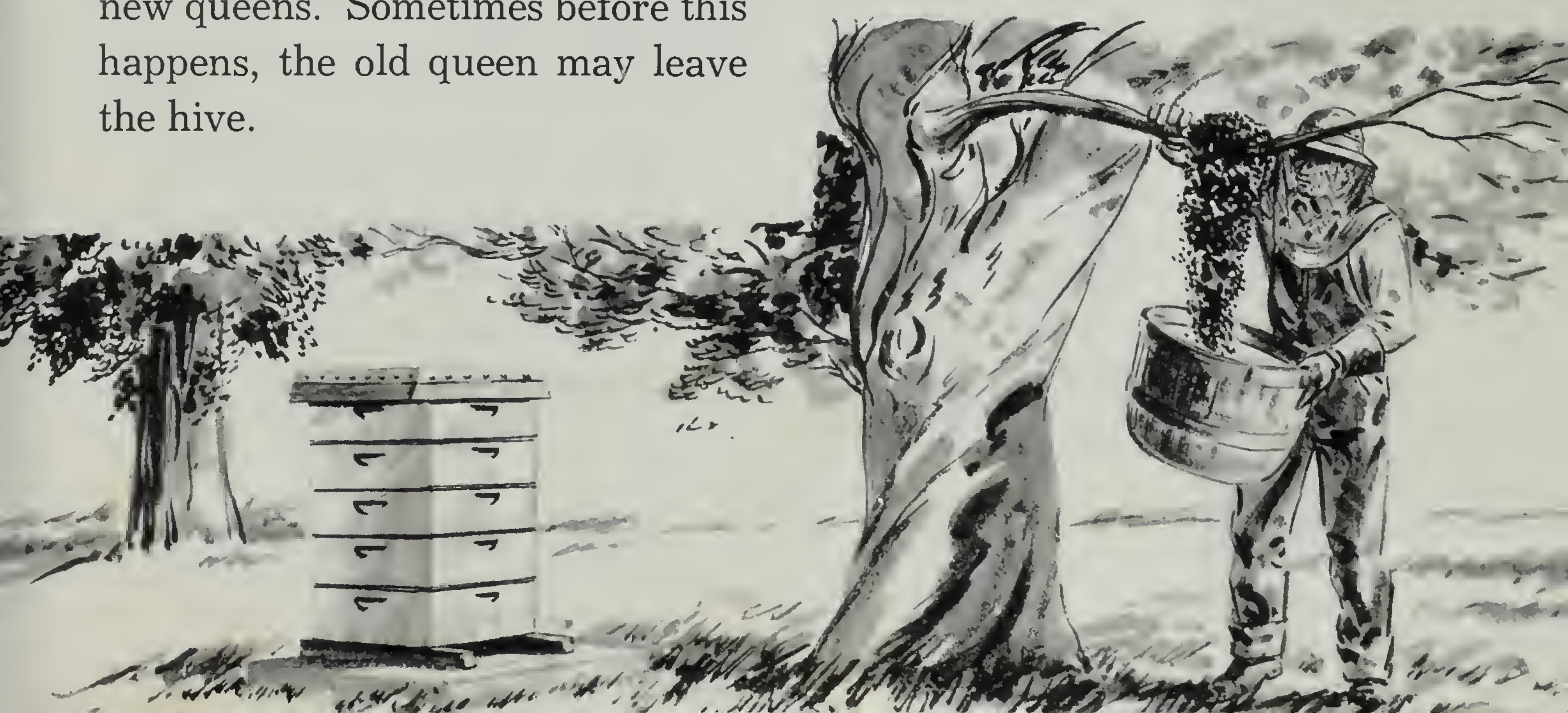
As you know, some of the eggs laid by the queen bee will hatch into new queens. Sometimes before this happens, the old queen may leave the hive.

Many bees leave with the old queen. They fly together in a swarm to a fence or tree that is near.

If a beekeeper wants the swarm for a new beehive, he puts on his mask and gloves. He carefully shakes the bees into a basket and places them in a new hive. For a day or two the door of the hive is closed so that the bees will become familiar with their new home.

The young queen remains with some of the bees in the old hive. She kills other queens that may be hatching by stinging them to death.

In this way new hives are started. In each hive each bee will do its own special work. The drones do little. The queen lays thousands of eggs, each of the several years that she lives. The workers work and work every day of their lives.




## Ants Are Social, Too

Ants are animals that are social in much the same way as honeybees. Neither ants nor honeybees are social in the way people are social. These animals live and work together. But they do not talk to one another. They do not sing and play together. They do not plan together, as people do.

An anthill is interesting to watch. Perhaps there is an anthill near your school that your group may visit. Watch the ants to see what kind of food they are bringing to the anthill. Put some sugar on the ground near the anthill and watch the ants find it and take it into the anthill.

Aren't these busy animals?

If you could see inside an anthill, you would find that ants live much the same kind of life that honeybees live. Each family of ants has its own anthill, just as each family of honeybees has its own hive. In an anthill you would find one queen ant, several male ants, and many, many worker ants.

In the spring young queen ants fly high into the air. Here each young queen mates with a male ant. Then each queen flies back to the earth and starts her own anthill. At this time she loses her wings.

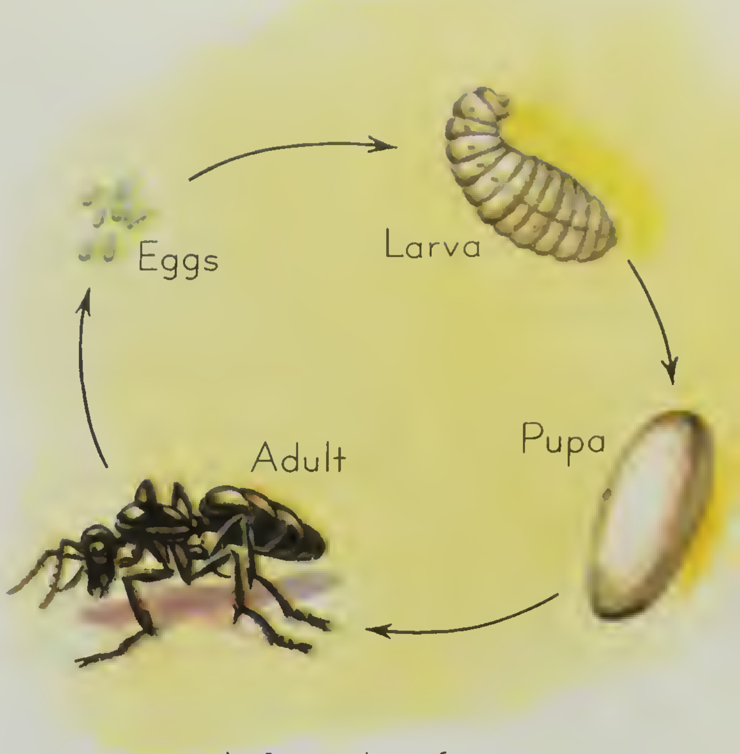
Worker ants are very busy. They may be nurses, builders, housekeepers, and sometimes soldiers.

The nurses care for the eggs laid by the queen. When the larvae hatch from the eggs, the nurses feed them from their own mouths. The nurses even keep the young ants warm by moving them from cooler to warmer places in the anthill.

After a while each larva spins a cocoon and rests. Often people feed ant cocoons to turtles. Often these cocoons are called ant eggs, but they really are not.

Young ants come out of the ant cocoons. Most of the young ants are workers. Some kinds of worker ants may take care of small animals called plant lice or aphids.

Aphids live on sap from plants. If the aphids are stroked, they give up some of the sweet sap. Ants like the sap, and so they stroke the aphids to get it. For this reason aphids are often called ant cows.



Life cycle of ant

Each ant has its own work to do, just like the honeybee. Each ant does its work just as other ants have done theirs for many, many years. But ants do not plan together, as people do.

# Animals Live in Different Ways

Some animals live a social life. Others live alone most of the year or all of the year. What are some of the advantages in these different ways of living?

Each way has some good and some bad things about it. It is hard to tell which way of living is better.

Let's think about food-getting for a moment. Most of the social animals are plant-eaters. They work together to get and store their food.

Many of the animals that live alone are meat-eaters. They hunt alone and do not store their food, since meat will not keep long.

When there is not enough food to go round, it is probably better to be a solitary animal. Social animals often use a great deal of one kind of food. If this food is scarce, the animals may have to go a long way to find it. It may be very, very hard to find enough of this food for all the animals in the family.

Yes, it is hard to know which way of living is best for these animals. There are advantages in each way of living. Each animal lives the way it is best adapted to live.

## FINDING MORE ABOUT SOCIAL ANIMALS

1. At the bottom of the opposite page is a picture of beavers at work near a beaver pond. Beavers are social animals. Often several beaver families will build houses in the same pond.

Find material to read that will help you to understand how beavers live and work together.

2. Termites are social insects that do much damage. They get into wooden buildings and eat away much of the wood from the foundations. The owner may not notice until after the damage is done.

Do termites do much damage in your region? How can buildings be built to stop this damage?

## THINK ABOUT THESE THINGS

1. If you walk through a meadow in the summer, you may disturb many, many grasshoppers. Do you suppose these are social animals? Or do you think there may be many grasshoppers in this place because there is plenty of food?

Some grasshoppers do great damage to crops. Find out if this happens in your part of the country. How can this damage be stopped?

2. Lions do not live together in large groups. Neither do tigers. Find out how these animals live and care for their young.

3. Barnacles are small-shelled animals which live in ocean water. They fasten themselves to the bottoms of boats or to docks.

Hundreds of these animals live near one another. Why do you think they live in this way?

## DO THESE THINGS

1. Explore your community to find some of the many animals living there. Make a map such as the one on page 228.

2. Have you ever visited in another part of the country? List the animals you saw there, but did not see in your own community.

# We Live and Work Together

## We Change as We Grow

Do you remember when you were a tiny baby? Of course not. You do not remember the day you first drank milk from a glass. You do not remember the first day that you talked or walked. You do not remember the way you looked then.

You have probably seen pictures of yourself that were taken when you were a baby less than one year old. You have seen other pictures taken when you were two or three or seven or eight years old. Find these pictures and look at them again. Haven't you grown! Haven't you changed!

Perhaps you and your friends would like to make an exhibit of such pictures so that you can see how you have grown and changed. Perhaps your teacher has some pictures of herself, so that you may see how she has grown and changed.

Arrange your pictures carefully and take good care of them. It is fun to have these pictures to look at over and over again.

# Changes to Expect in Growing Up

Think of the changes that have taken place in your body as you have been growing up. Ask your mother how much you weighed when you were born. Was it about 7 pounds? Certainly you have grown heavier.

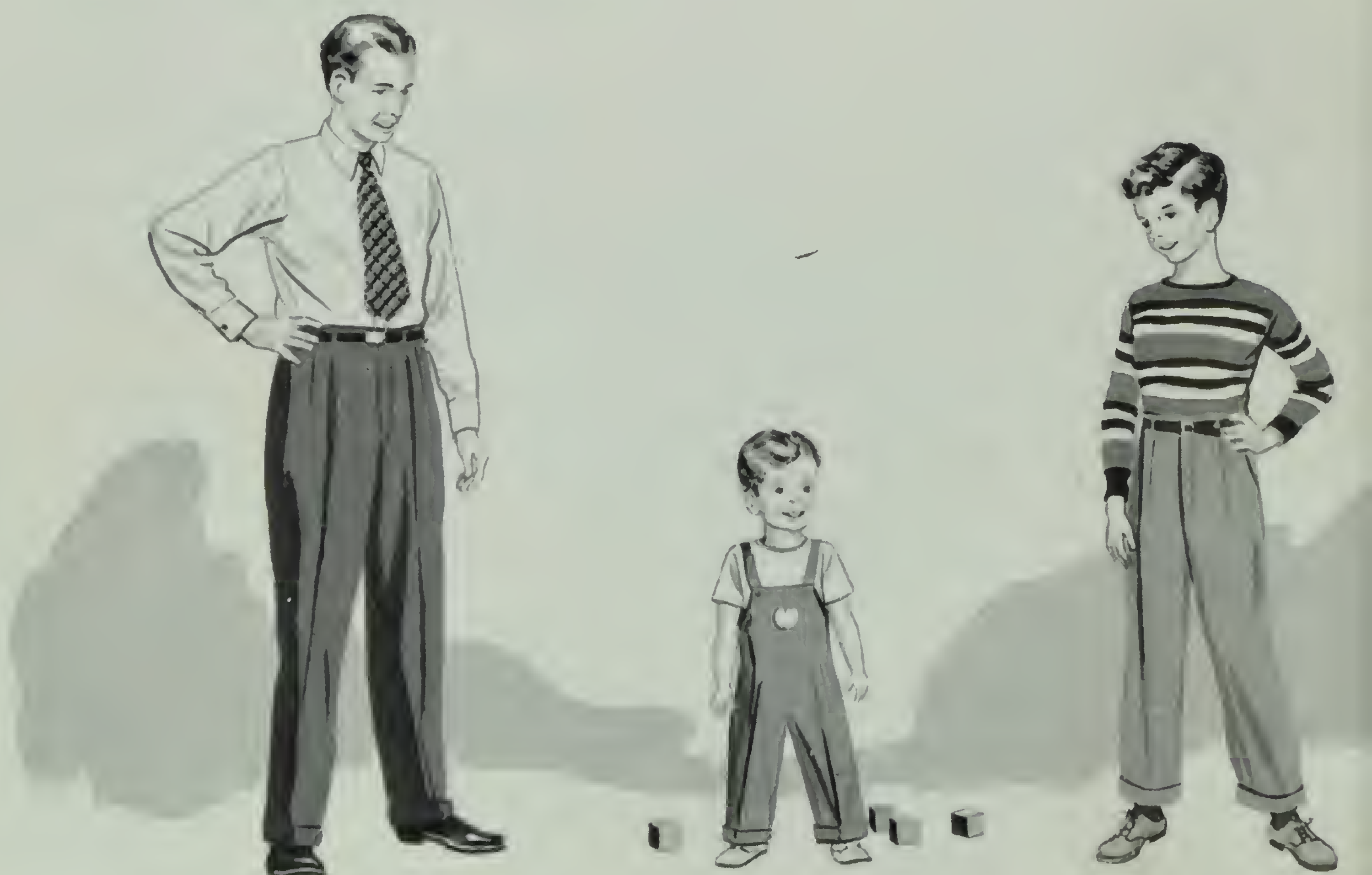
Ask your mother how long you were when you were born. How much longer you are now!

Your father and mother were once very small also. All adults were. They have grown longer and heavier as they have grown older.

Of course we do not get taller and taller and taller as we grow older. Most people stop growing when they are in their late teens or early twenties.

Some people do not grow much after they are fourteen or fifteen. Each person stops growing at a different time. Each person grows at a different rate.

Also, different parts of our bodies grow at different rates. Look at the pictures of the man, the boy, and the baby below.



| Heights of Our Fathers | | |
|---|---|---|
| Fathers | Heights | Heights of Fathers' Parents |
| Mr. Baker | 5 feet 7 inches | Father: 5 feet $7\frac{1}{2}$ inches<br>Mother: 5 feet 3 inches |
| Mr. Case | 6 feet $2\frac{1}{2}$ inches | Father: 6 feet 2 inches<br>Mother: 5 feet 7 inches |
| Mr. Davis | 5 feet $11\frac{3}{4}$ inches | Father: 5 feet $11\frac{1}{2}$ inches<br>Mother: 5 feet $6\frac{1}{4}$ inches |
| Mr. Douglas | 6 feet $\frac{1}{4}$ inch | Father: 5 feet $10\frac{3}{4}$ inches<br>Mother: 5 feet 9 inches |

Notice how large the baby's head is in comparison with the rest of its body. Is this true of the man's head? Do you suppose a child's head becomes smaller as he grows older?

No. A child's head is growing. But it doesn't grow as rapidly as other parts of the body, such as the legs and arms.

Right now your legs and arms are growing pretty fast. If they aren't, they will be soon. But all parts of your body are growing.

Sometimes boys and girls wonder how tall they will be. One way to make a good guess about this is to find out how tall their fathers and mothers are.

Many times boys grow to be about as tall as their fathers. Girls grow to be about as tall as their mothers. Sometimes children may not grow as tall as their parents.

Above is a chart that one group of children made when they became interested in this problem. This chart shows the heights of some of the fathers. It also shows the heights of the mother and father of each father.

Notice that each of the fathers is about the same height as his father. Today many boys grow to be a little taller than their fathers. Many girls grow to be a little taller than their mothers. This may happen because of eating more healthful foods.

It is hard to tell just what height you will be when you stop growing. Right now you may be the tallest child in your group. Or you may be short or of medium height.

Perhaps your group might like to make a chart showing the height of each girl and boy in the group. The chart below was made by a group of children about your age.

Find the tallest person on the chart. Yes, it is Betty. Very often girls of ten or eleven are taller than boys their age. Some girls start to grow tall earlier.

This chart shows that Amy is the shortest person in the group. Sometimes a boy is the shortest person in a group. These people may always be the shortest people in their group, but very often they are not. As they grow older, they may begin to grow taller.

You should not worry about your height. You may expect to be about as tall as your father if you are a boy. You may expect to be about as tall as your mother if you are a girl. Very often you will be a little taller.

The height of a person does not matter very much. Some adults wish that they were a little shorter. Others wish that they were a little taller. But tallness or shortness is not very important.

There are other things that are far more important. The way a person stands is important. How clean a person keeps himself is important. But also important are the way a person thinks and the way a person plays and works with others. These things are much more important than the height or weight of a person.

**Our Heights**

| | | |
|---|---|---|
| Amy | 4 feet | 0 inches |
| Allen | 4 feet | $2\frac{1}{2}$ inches |
| Albert | 4 feet | 10 inches |
| Bert | 5 feet | 3 inches |
| Betty | 5 feet | $3\frac{1}{2}$ inches |
| Dave | 4 feet | $7\frac{3}{4}$ inches |
| Frances | 4 feet | $7\frac{1}{4}$ inches |

Our bodies change in other ways too. Our weight changes as we grow. Our chest measure changes. Our waist measure changes, too. Our feet also grow.

Color of hair often changes over the years. Perhaps you had light hair when you were a baby. Now it may be brown.

Has the color of your eyes changed? Ask your parents to tell you what color your eyes were when you were first born. Did you have blue eyes then? Are they brown now?

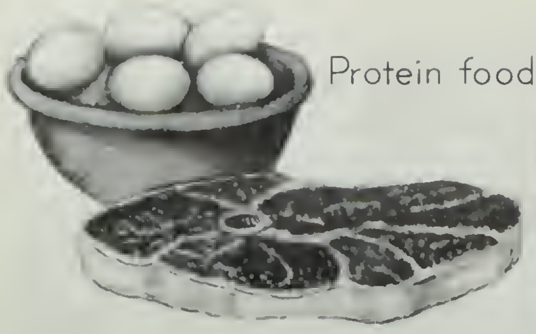
Color of eyes, then, can change. But you may expect the color of your eyes to change very little from now on. Sometimes blue eyes are a little lighter when a person is older, but they remain blue.

Your voice will change, too. It may even be changing now. Boys' voices become deeper. Girls' voices become fuller and richer.

We may change in another important way as we grow older. Many of us will learn to work together better.

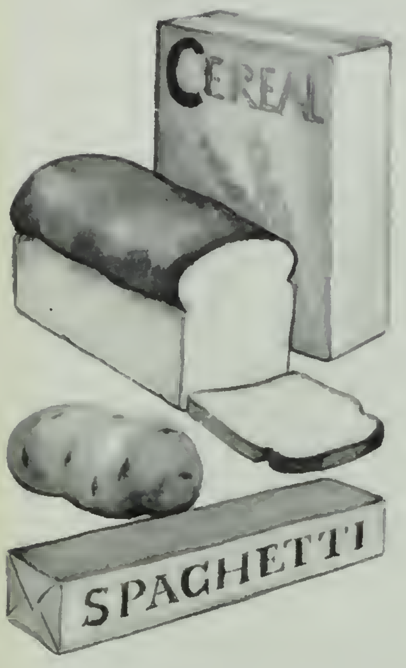
Above is a picture of some children who are about three years old. Notice how they are playing together. Children of this age often tussle over toys. They usually play alone, even though they are near other children.

By now you have learned some good ways to think and work and play together. You are learning more and more about how to cooperate and how to plan together. This is important.



Protein foods


# Eating for Good Growth




Carbohydrate foods

Ten-year-old boys and girls are all different from one another. So are eleven-year-old boys and girls. So are babies. So are men and women. But one way that boys and girls are alike is that they are growing all the time.

We can't plan to make ourselves taller or make ourselves shorter. But we can plan for better bodies. We can plan to be healthy and strong.

One way to be healthy and strong is to have plenty of rest. Another way is to have several hours a day of play in the fresh air.

We should also include in our plans the right kinds of food. These do not need to be expensive or fancy foods. But we should try to have certain kinds of food each day. The pictures on these pages show important groups of food that we should plan to eat.

Probably you know why you should eat these foods. Eggs, meat, dried beans, dried peas, fish, cheese, and soybeans are among the foods we should plan to eat for proteins. Proteins help new cells grow.

Our bodies are made up of many cells of different kinds, such as skin and bone cells. Some of the cells are always dying. New ones are always growing. Foods rich in proteins help our bodies to replace old cells and to form new ones.


Calcium foods

Yellow and green vegetables

Every day you use up a great deal of energy. This is because you run, skate, play ball, and help with chores about the house. Foods containing carbohydrates and fats give up a good deal of energy. Such foods are butter, bread, potatoes, cereals, spaghetti, macaroni, and meat. Plan to eat energy-giving foods, containing carbohydrates and fats, each day.


Fat foods

Our bodies also need minerals. Calcium is a mineral that helps us to build strong bones and teeth. Plan to eat such calcium foods as milk, cheese, butter, and green, leafy vegetables. Remember that we also need several glasses of water each day.

Vitamins are body-builders, too. Yellow vegetables, green, leafy vegetables, liver, cream, cheese, and butter are rich in vitamin A. This vitamin helps us see well and have clearer skins and stronger gums.

Whole-grain cereals, nuts, dried peas and beans, fruits, milk, green vegetables, fish, meat, and liver are rich in vitamin $B_1$. This is the vitamin that helps us to have a good appetite, to digest our food, and to have steady nerves. Plan to eat foods that contain vitamin $B_1$.

Vitamin $B_2$ was at one time called vitamin G. It is a vitamin that helps us to have steady growth and a clear skin. Plan to eat apples, apricots, meat, liver, green vegetables, milk, salmon, tuna, and yeast so that your body may have plenty of vitamin $B_2$.

Fruits

Vitamin-C foods help blood vessels and our gums to be strong and healthy. Some vitamin-C foods are Brussels sprouts, cauliflower, cabbage, broccoli, green asparagus, oranges, bananas, kale, grapefruit, peppers, apples, and cantaloupe. What good foods these are! And how good they are for us!

Another important vitamin is vitamin D. We get vitamin D from sunlight, as well as from foods.

The foods we eat for vitamin D are butter, milk, liver, salmon, tuna, and cod-liver oil. This important vitamin helps us to have strong, straight bones.

We can help ourselves by eating the right amounts of the good foods our mothers prepare for us. We know that eating too much does not make strong, healthy bodies. But eating the right amounts of the right kinds of foods does this for us.

## Planning Together

You began to think and plan when you were very young. Little children learn how to build with blocks. They can follow directions and can help around the house. Soon they begin to go to school.

School is a place that should help you to be a better planner. Here, too, you learn to work with others in better and better ways. This is the beginning of good planning.

You are able to listen. You are able to talk about your ideas. The whole group plans together.



Reading also helps you in planning. You are able to use information that others have discovered. New ideas come to you from books.

It is a wonderful thing to be able to get information by reading. Did you know that people are the only living things who can learn by reading?

What are some other things you can plan to do? You can write, of course. Do you send ideas to people in other cities? You can do this by writing letters.

One of the most important ways to share ideas is by talking. We are the only living things able to plan and share in this way.

Your dog sometimes seems to understand what you say to him. But he can never say to you that he understands.

Once upon a time people could not talk to one another, either.

Languages had to be invented. Certain sounds began to have certain meanings. These sounds became a language.

Sound this letter to yourself: *e*. Do you think of the letter *e*? This same sound would mean "and" to a Spanish-speaking child. You may not understand languages other than English. But you could learn them. You would then be able to share ideas in other languages.

There are other ways of sharing and planning. Have you ever thought of planning for a quiet time? Each of us needs just such a restful time each day.

Think of your whole day. Could you plan better ways in which you might use your time?



## Planning for Animals

People have lived in North America a long, long time. The people who first lived here, so far as we know, were Indians. Indians were probably the first Americans.

Indians have been living in North America for hundreds of years. About four hundred years ago people from other lands began to come to this country to live.

There were a great many wild birds and mammals living in North America before people from other lands came. Deer, foxes, wolves, mountain lions, wildcats, rabbits, bears, weasels, and many, many other animals roamed the forests.

In the forests and grasslands turkeys, partridges, quail, and doves lived. Thousands and thousands of wild ducks and geese lived in the marshy lands.

Huge herds of bison lived on the broad, grassy plains. Every year the Indians who lived on the plains hunted the bison. They killed these animals with bows and arrows. Bison were not hunted and killed just for fun. Indians used them as food.

Other animals were killed for food or for clothing or for both. Indians used the skin and fur of animals for clothing and for summer tents.

Though many birds and mammals were killed by Indians, there were still thousands and thousands of wild animals left when people began to come to North America from other lands. One reason was that there were not a great many Indians living in this huge country called North America.

The first people who came to this country from other lands killed animals wisely, too. They killed animals for food and clothing. There were many fish, many birds, and many mammals to use for food. It was right for a man to make good use of these animals when he needed them for food and clothing.

After a while these people had plenty of domesticated animals to use for food. They raised chickens and pigs and cattle for food. They had plenty of eggs, butter, milk, and cheese. Men did not need to hunt the wild animals as much as they did before. But some of them killed the wild animals just for the fun of killing them.

Before many years passed, people began to notice that the deer were disappearing from the forests. Only a few bison roamed the grassy plains. Then men began to realize that something must be done.

Finally, people began to plan for wild animals. They wanted deer in the forests. They wanted ducks and geese in the marshes. They wanted fish in the streams. If these animals were to stay, they had to be protected. People had to plan for them. So they did.

People came together in groups and talked about how to protect wild life. They decided that laws must be passed to protect wild animals.

Laws were made and passed. Deer, doves, quail, wild geese, wild ducks, and many other animals may be hunted only at certain times of the year.

Do you think people should be allowed to hunt wild ducks while the mother ducks are hatching their eggs? Do you think people should be allowed to hunt ducks before the ducklings are full grown? Why do you feel the way you do about this?


## Hunting and Fishing Today

Today wild ducks are protected from the hunter most of the year. Ducks may be hunted only for a short time in the fall. By that time of the year all the ducklings have been hatched. The mother and father ducks no longer have to take care of their young.

Ducks are protected in another way too. A hunter is not allowed to kill as many ducks as he can. Each hunter is allowed to kill only a few ducks during the hunting season. Laws have been passed that tell how many ducks may be killed by a hunter in one day. It is important that these laws should be obeyed.

Many hunters are good sportsmen and do not try to kill more ducks than they should. Because some hunters are poor sportsmen, there are "wild-life policemen," who watch for them.

These policemen are called game wardens. Their job is to see that no hunter kills too many ducks or other wild game.

Most wild game are protected in the same way that ducks are. Hunters and fishermen must have a license before they can hunt and fish.

They must keep this license with them while they are hunting and fishing. If a game warden asks to see the license, they must show it.

See how many reasons you can think of why people should buy a license before they hunt or fish.

One good reason is that the game wardens can tell how many people are hunting or fishing for a certain kind of animal each year. When they know how many hunters there are, they can decide how many of each kind of animal a hunter or fisherman may kill.

In some places certain wild animals may not be killed at all. Because these animals have become very scarce, no one is allowed to kill them.

It is possible to make and observe laws protecting wild animals. By doing these things, we shall always have enough wild animals in North America.

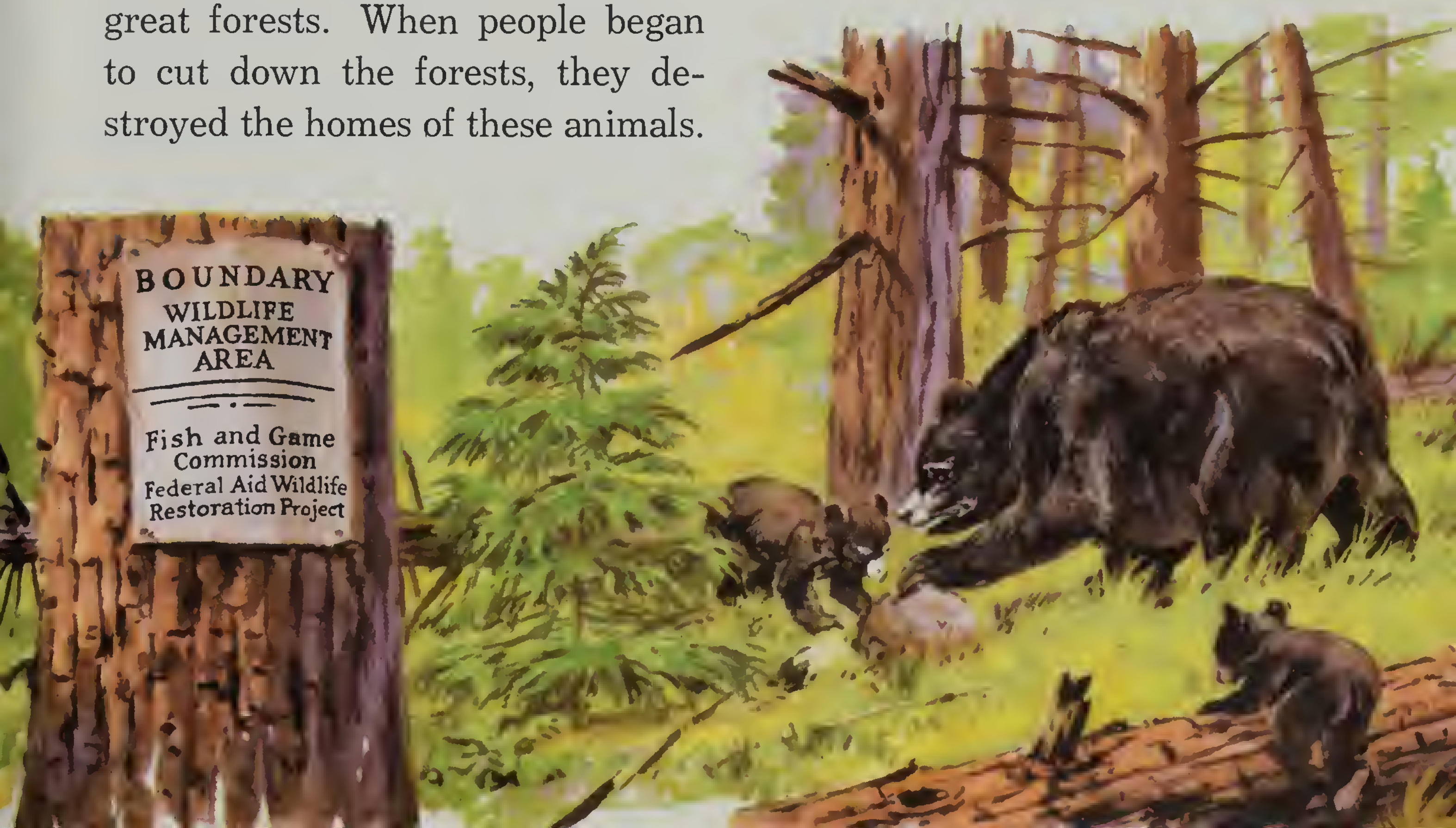
## Homes for Wild Animals

We are learning to protect wild animals in still another way. For a long time people destroyed the homes of animals. They did not mean to do this. They just didn't think.

The great forests of North America were the homes of millions of wild animals. They hid from their enemies in the bushes and among the trees. These animals could not live safely anywhere except in the great forests. When people began to cut down the forests, they destroyed the homes of these animals.

Many young forest animals never lived to be full grown, because they were not protected. They could not escape their enemies, nor could they find a place to hide.

We have learned to protect these animals of the forests. Our national governments and state and provincial governments protect certain forest areas so that our wild, forest animals can have homes.



When people began to cut wild grass on the broad plains of North America, they destroyed the food and homes of many wild animals. Great herds of bison fed on this tall grass.

After the grass was cut and the land was plowed, there was not enough food for these and other animals. Soon there were fewer and fewer of these animals.

Then people began to realize what was happening. They set aside certain grasslands as grazing land for bison. They passed laws that no one could kill these animals. No one was allowed to destroy their food by plowing this land to raise wheat or corn. Because we were finally wise enough to set aside such grasslands, there are still bison in North America.

Quail and doves made their homes in the grasslands. Their homes were also destroyed when the grass was cut.

Farmers liked to keep their land neat and clean. Some of them allowed no grass or bushes to grow between their fields of corn and wheat and rye. Soon there were no homes for the grassland birds.

After a while the farmers realized that many of the birds were gone. Then they began to let the bushes, vines, and grass grow along the fences between the fields. Now there are homes for quail, doves, and other birds, as is shown in the picture above.

Birds are being protected in other ways too. No one is allowed to hunt certain birds that are scarce. In some places there are special areas set aside for birds. These places are called bird sanctuaries.

Some bird sanctuaries are in marshy places. Here cranes, herons, ducks, and geese are safe. Sanctuaries are also provided for forest birds. People may visit these places, but they may not harm the birds.

## Producing New Animals

There is still another way that man plans for animals. He plans how he may have new and stronger domesticated animals that may be used for food and clothing.

Certain kinds of chickens are good egg-layers, but are not meaty. Other chickens have much meat, but do not lay many eggs. So farmers produce new chickens by crossbreeding.

In crossbreeding, the father is one kind of chicken, and the mother is another kind. Such chickens as Plymouth Rocks and Rhode Island Reds have been produced by crossbreeding. These chickens are meaty and are good egg-layers.

Recently a new kind of sheep was brought from Australia. Its name is the Australian Merino. This sheep has very fine wool. The sheep of North America have strong bodies, but their wool is not as fine as that of the Merino.

It is hoped that a new sheep may be produced by crossbreeding the Merino with the sheep of North America. It is hoped that the new kind of sheep will have a strong body and very fine wool.

It was found that Jersey and Guernsey cattle living in the southern part of the United States were not as strong as those in other sections of the country. It is too warm for them there. These cattle first came from the British Isles, where it is much cooler.

So people began to study cattle in order to find a kind that could live well in a warm climate. They found that the Brahman cattle of India were strong and healthy, although they lived in a hot climate. So these cattle were crossbred with Jersey and Guernsey cattle to produce strong milk cattle.

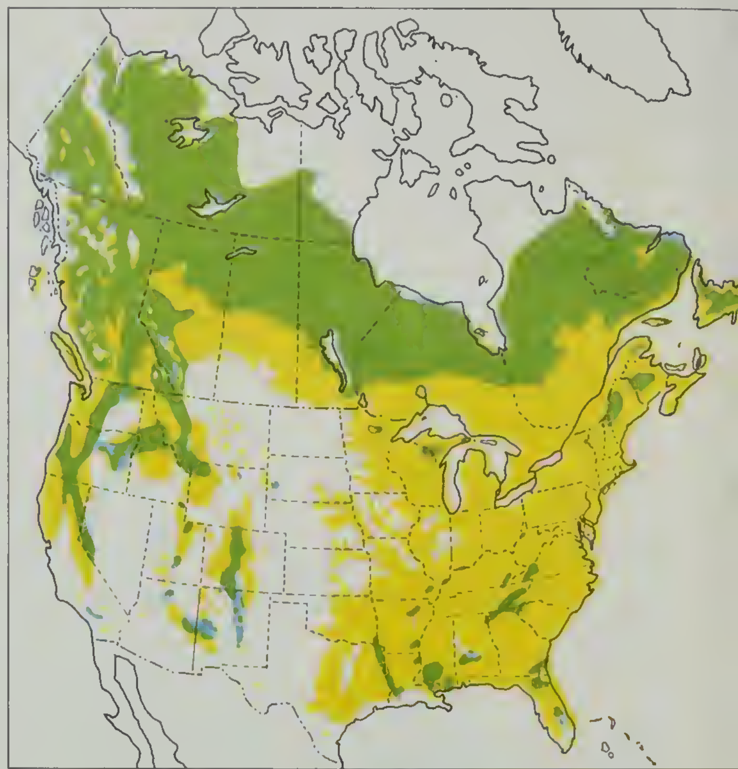
People plan for animals in many wise ways.

Australian Merino

Brahman

FORESTS LONG AGO

FORESTS TODAY




# Planning for Forests

The map above on the left shows where there were forests in Canada and the United States about three hundred years ago. The map on the right above shows what part of those native forests remain today.

There were good reasons why the native forests were cut down. Early settlers needed wood for homes, for fires, and for ships.

For a long time every tree was cut down in certain areas. After a while the people began to realize that they must not cut too much wood. They began to plan ways to protect the forests.

In some government-owned forest lands no one is allowed to cut trees without special permission. Also we have learned to cut our trees in such a way that the land keeps growing new forests.

Then, too, we plan the planting of trees on old and new forest land. Young trees are sometimes planted to take the place of those cut down or destroyed by fire. Also, whole new forests are being planted.

Small forests are sometimes called tree farms. People have discovered that they can have a crop of trees, just as they have a crop of corn or wheat or cotton.

Cutting too many trees is not the only danger to forests. One of the greatest dangers is fire. All over North America people are planning better ways to keep forests alive.

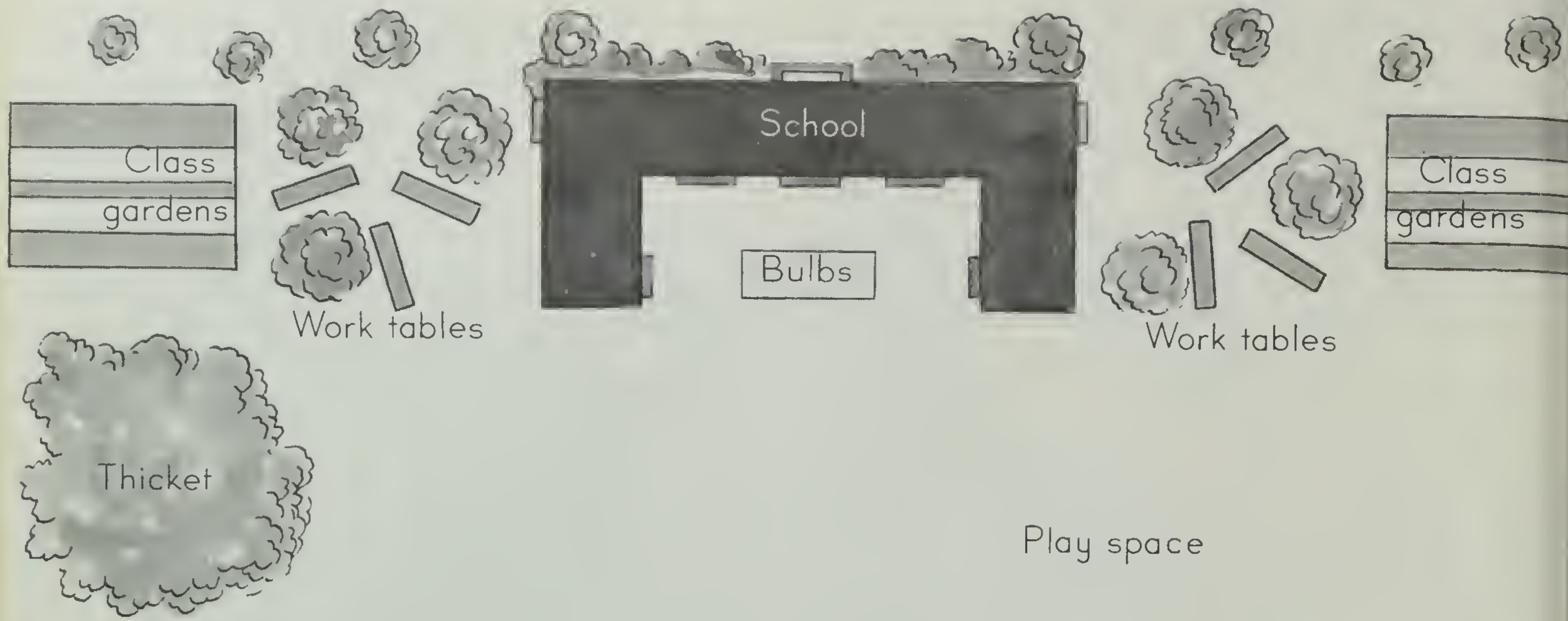
Many forest areas of Canada are usually dry in summer. Below is a poster that might be used to remind people of the danger of fire.

In large forests the government sometimes builds special towers. In each of these towers a fire warden is on duty every hour of the day and night to watch for forest fires.

Terrible fires are sometimes started by lightning. Campers who are careless with cooking fires or with matches or cigarettes sometimes start a dreadful fire.

Certain insects damage our trees. Douglas firs and spruce trees are damaged by the spruce budworm. In order to kill harmful insects, poisons are sprayed on forests from airplanes.

So each year we must plan together wisely to protect our trees. Then we will have enough lumber for many uses.




## Planning for Other Plants

The new Jackson School was finished at last! At least, the school was finished, but the grounds were not. There was no grass on the lawn, and there were only a few trees here and there. There were no shrubs nor flowers. Without these plants the grounds were not pretty.

But the school grounds could be changed. All the children had been given a chance to tell what they would like to have in their new building. Now they would have a chance to help make plans for beautiful grounds. Each group began thinking about how it would like to have the school grounds look.

A group of teachers and a few children from each classroom worked together on the plans. Other children, other teachers, the principal, the custodian, and parents made suggestions.

Here are some of the things they wanted on their school grounds:

1. A green lawn and shrubs
2. A garden space for each group
3. A bulb garden in the spring
4. A thicket where wild plants could grow well
5. Trees to make a shady working place
6. Play space

The picture on the opposite page shows how the group made plans for the plants they wanted at school. Have you thought of helping to plan for plants around your building or around your home? You could do it.

People plan for plants in various ways. Some men and women make a lifework of working with plants. They plan ways of improving plants.

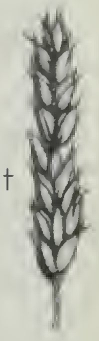
Wheat, corn, rye, and barley have been improved by men. Marquis wheat was developed by Mr. C. E. Saunders from Red Calcutta wheat and Red Fife wheat. Marquis wheat is much better than either of its parents because it produces more grains of wheat, produces better wheat, and grows faster.

Cotton plants have also been improved, but people are still trying to think of ways to grow better plants. They are working to produce cotton plants with long, strong fibers and cotton bolls that will develop quickly. When cotton bolls develop quickly, the plants will produce cotton before cotton-boll weevils harm them.

Luther Burbank was a great experimenter with plants. His work with field daisies gave us the beautiful Shasta daisy. The large, firm Burbank potato was developed from the small Early Rose potato. Burbank also developed cactus plants without spines. The plants without spines can be eaten by animals.

Yes, we can make plans for plant life. Some of us may want to do this as a lifework.

Red Calcutta wheat



Red Fife wheat

Marquis wheat

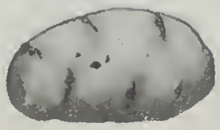
Common field daisy

Prickly-pear cactus

Spineless cactus

Early Rose potato

Burbank potato



Shasta daisy

# People Are Planners

People are planners. We are planners because we are thinkers. We are able to make plans for good farms. Some people are able to use land wisely to raise plants.

Farmers know what kinds of food people need. Each year they try to raise better wheat, better corn, better fruits, and better vegetables.

Farmers know that people need meat for food. So they are always interested in the kind of animal that will produce better pork, better lamb, or better beef. They are eager to raise healthy milk cows in order to produce good cream, milk, cheese, and butter.

They also want animals that will produce better wool for clothing and better hides for shoes.

People exchange ideas about their plans for plants and animals, about their plans for better health, and about better places to live and work. Ideas can be exchanged by talking with one another. Still another way of exchanging our ideas is by writing and reading.

We talk about new things that other people have done. We read about new things. We see pictures of them. In these ways we learn how to plan to do new things ourselves. No other living thing can do this kind of planning.

Our most beautiful cities have been planned. The more carefully we plan, the more beautiful and useful we can make our cities. Was the town, village, or city where you live planned?

It is possible to build or rebuild a city so that there is plenty of good living space for everyone. It is possible to build or rebuild a city so that there is plenty of room for children to play, a city where it is easy to travel from one place to another.

Look about the community, wherever you live. Could it be made more beautiful, more livable? Are there plans to change it?

As you grow older, you will be asked to help plan a better community and to see that these plans are carried out.

If you begin to think about these things now, you will be a more useful member of your community.

Not everyone plans alike. For instance, someone in your community may be planning a new home. He may plan to build his house of brick. Another may be planning to build of wood.

Someone living in the jungles of Brazil is also planning his home. He is planning to build his house of slender tree trunks and large leaves. All these people are thinking and planning.

Although people may have different languages, or color of skin, or customs, or height, or weight, they are alike in many ways. One of these ways is that they can learn to plan and work well together.

## THIS IS FOR YOU

1. Make a list of the things you do to help at home and at school. How many new things can you add to your list?

2. If you live on a farm, ask your father to tell you what are his plans for protecting the land, the plants, and the animals on his farm.

3. Plan a luncheon for your schoolmates. Think about the foods that help to make a strong, healthy body. Here is a menu prepared by one group. Why is it a good menu?

Our Luncheon Menu

Hot vegetable soup
Peanut-butter sandwiches on whole-wheat bread
Carrot sticks
Fruit
Milk

4. Find out how wild animals are protected in your state or province. Write your state or provincial game commission to learn which animals are protected. Ask what are the dates of the open seasons for hunting certain animals. Ask how many of each kind of animal a hunter may kill.

5. Most wild flowers are beautiful. So people like to pick them and take them home. Often the flowers wilt and soon die. Find out which wild flowers are protected in your state or province. Do not pick them.

6. Many trees are destroyed each year by fire. When you are on a picnic, what rules should you practice to prevent a fire?

# Science Words

This part of your book is a science dictionary. It will help you find the meanings of words which are used in your book. The page number following each word shows you on what page the word is first found.

The following list of letter sounds will help you to use correctly the markings of your science words.

| | | | |
|---|---|---|---|
| ă *as in* căt | ẽ *as in* hẽr | ô *as in* hôrse | oi *as in* soil |
| ā *as in* māde | ê *as in* bêgin | ô *as in* ôbey | o͝o *as in* to͝ok |
| ȧ *as in* gràss | | ǒ *as in* sǒft | o͞o *as in* mo͞on |
| â *as in* câre | ĭ *as in* gĭft | | ng *as in* sing |
| ä *as in* bärn | ī *as in* rīde | ŭ *as in* cŭp | th *as in* thin |
| | | ū *as in* mūsic | th *as in* that |
| ĕ *as in* nĕt | ŏ *as in* tŏp | û *as in* bûrn | tû *as in* pictûre |
| ē *as in* hē | ō *as in* jōke | û *as in* ûnite | |

**ac′id** (ăs′ĭd). Things which taste sour contain acid. Vinegar contains an acid (p. 126).

**air pres′sure** (âr prĕsh′ẽr). The push, or force, of the air, even on a still day. Air has pressure because it has weight (p. 51).

**al′co hol** (ăl′kô hŏl). A liquid which may be used for rubbing the body. Rubbing alcohol makes the body feel cool (p. 28).

**al′ka li** (ăl′kȧ lī). Things which taste harsh or bitter contain alkali. Baking soda is an alkali (p. 126).

**a lu′mi num** (ȧ lū′mĭ nŭm). A light-weight, bluish, silver-white metal. Aluminum is used to make pans, trays, airplanes, and many other things (p. 43).

**am phib′i an** (ăm fĭb′ĭ ăn). A group of animals which have backbones and which get air from the water during the first part of their lives. Later these animals have lungs and get air as we do. Frogs and toads are amphibians (p. 143).

**an′e mom′e ter** (ăn′ê mŏm′ê tẽr). An instrument which measures the speed of the wind (p. 63).

**an′er oid ba rom′e ter** (ăn′ẽr oid bȧ rŏm′ê-tẽr). An instrument which measures air pressure. This kind of barometer uses no liquid (p. 50).

**a quar′i um** (ȧ kwâr′ĭ ŭm). A tank in which to keep water plants and animals (p. 160).

**as tron′o mer** (ăs trŏn′ô mẽr). A person who studies sky bodies (p. 86).

**at′mos phere** (ăt′mŏs fēr). The air; the layer of gases around the earth (p. 67).

**at′om** (ăt′ŭm). The smallest piece into which an element can be divided and still be an element (p. 112).

**ax′is** (ăk′sĭs). The imaginary straight line from the north pole through the center of a planet to its south pole. The earth turns upon its axis (p. 78).

**ba rom′e ter** (bȧ rŏm′ê tẽr). An instrument which measures air pressure (p. 46).

**bee′bread′** (bē′brĕd′). Food made by older bees for the young bees before they are able to fly and get their own food. It is made of pollen and nectar (p. 248).

**bee′tle** (bē′t′l). An insect which has four wings. The outside pair of wings make a stiff covering for the body when the wings are folded. Potato bugs, ladybirds, and cotton-boll weevils are beetles (p. 129).

**bird** (bûrd). Any animal which has feathers on its body (p. 16).

**boll** (bōl). The seed pod of a plant such as cotton or flax (p. 129).

**boll wee′vil** (bōl wē′v′l). A beetle which lays its eggs in the bolls or in the flower buds of cotton plants. A full-grown boll weevil is about $\frac{1}{4}$ inch long (p. 129).

**bo′ron** (bō′rŏn). One of the elements of which the earth and everything on it is made. Boric acid and borax contain boron (p. 127).

**cal′ci um** (kăl′sĭ ŭm). One of the elements of which the earth is made. Milk contains calcium. We need calcium to build strong teeth and bones (p. 113).

**car′bon** (kär′bŏn). One of the elements of which the earth is made. Plants, animals, coal, and oil contain carbon. Diamonds are a form of carbon (p. 112).

**car′bon di ox′ide** (kär′bŏn dī ŏk′sīd). One of the gases found in the air. It is used by green plants to make food. Frozen carbon dioxide is called dry ice (p. 28).

**cell** (sĕl). A very small, box-like space. The small, box-like spaces in a honeycomb are called cells. Every living thing is made up of one or more cells. Of course these cells are not made of the same things as a cell in a honeycomb. But the shapes are much the same (p. 232).

**cen trif′u gal force** (sĕn trĭf′ū găl fōrs). When anything is moving in a circle or part of a circle, this force causes that thing to try to move away from its circular path (p. 169).

**chem′i cal** (kĕm′ĭ kăl). Everything is made of chemicals. Air, water, animals, plants, stones, and the earth itself are made of chemicals (p. 110).

**chlo′rine** (klō′rēn). One of the elements of which the earth is made. When it is pure, it is a greenish-yellow gas. Table salt contains chlorine (p. 113).

**chrys′a lis** (krĭs′ȧ lĭs). The covering of a butterfly when it is in the third, or resting, stage of its life (p. 138).

**cir′cuit** (sûr′kĭt). A path for electricity (p. 112).

**cir′ro-cu′mu lus** (sĭr′ō kū′mū lŭs). A high, white cloud which looks something like ripples of sand on the seashore (p. 57).

**cir′rus** (sĭr′ŭs). A thin, white cloud which floats in the air, 3 to 6 miles above your head. This cloud is so thin that you can see through it (p. 56).

**cli′mate** (klī′mĭt). The average condition of the weather at any place (p. 99).

**co coon′** (kŏ ko͞on′). The silky shell, or case, spun by the caterpillars of some insects, especially moths. Moths spend the third, or resting, stage of their lives in a cocoon (p. 138).

**cold′-blood′ed an′i mal** (kōld′blŭd′ĕd ăn′ĭ-măl). An animal whose blood is about the same temperature as the water or air around it. Snakes, frogs, and fish are cold-blooded animals (p. 103).

**com′et** (kŏm′ĕt). A sky body which follows an egg-shaped path around the sun. Comets are probably made of gases and small pieces of solid material. Comets usually have tails millions of miles long. Few comets can be seen without a telescope (p. 74).

**com′pound** (kŏm′pound). A substance which is made of at least two different elements. Water is a compound made of hydrogen and oxygen. Table salt is a compound made of sodium and chlorine (p. 113).

**con dense′** (kŏn dĕns′). To come together into a smaller space (p. 40).

**con duc′tor** (kŏn dŭk′tẽr). A substance which allows electricity or heat to go from one place to another (p. 208).

**con′tour-plow** (kŏn′to͞or plou). To plow following the curve of the land (p. 197).

**con tract′** (kŏn trăkt′). To become smaller in size (p. 31).

**cop′per** (kŏp′ẽr). One of the elements of which the earth is made. Copper is a reddish metal. It is a good conductor of heat and electricity (p. 32).

**cor′al pol′yp** (kŏr′ăl pŏl′ĭp). A very small, soft, sea animal which builds a hard covering of limestone around itself. Millions of these skeletons form coral islands (p. 237).

**cross′breed′** (krŏs′brēd′). To produce young from a female of one type of plant or animal and a male of another type of plant or animal (p. 269).

**cu′mu lo-nim′bus** (kū′mū lō nĭm′bŭs). A tall, heavy, dark cloud from which rain, snow, or hail may fall. These clouds may also be thunderheads (p. 58).

**cu′mu lus** (kū′mŭ lŭs). A thick, large cloud with a flat bottom and rounded top which looks something like a mountain. These clouds look very white when they are opposite the sun (p. 56).

**de gree′** (dē grē′). A space, or division, marked on a thermometer (p. 31).

**del′ta** (dĕl′tȧ). The large, fan-shaped deposit of soil which has been formed at the mouths of rivers, such as the Nile and the Mississippi (p. 194).

**di am′e ter** (dī ăm′ē tẽr). A line through the center of a circle or a ball (p. 75).

**di′no saur** (dī′nō sôr). Any of a group of reptiles which lived on the earth millions of years ago. *Dinosaur* means terrible lizard (p. 100).

**di′o ra′ma** (dī′ō rä′mȧ). A model which represents a scene. A diorama usually has a curved, painted background and models of plants, animals, or buildings in the foreground (p. 109).

**dis solve′** (dĭ zŏlv′). To become a part of a liquid (p. 126).

**do mes′ti cat ed** (dō mĕs′tĭ kāt ĕd). Tamed. Horses, cows, dogs, and cats are domesticated animals (p. 156).

**drone** (drōn). A male, or father, bee. Drones do no work (p. 246).

**dry cell** (drī sĕl). Chemicals in a sealed container which produces electricity. Dry cells are used in flashlights (p. 212).

**e clipse′** (ē klĭps′). The passing of the moon between the earth and sun so that the sun disappears. Or the passing of the earth between the moon and sun so that the moon disappears (p. 72).

**e lec′tro mag′net** (ē lĕk′trō măg′nĕt). A magnet made by winding an insulated wire around a piece of soft iron. When electricity goes through the wire, the iron becomes a magnet (p. 218).

**el′e ment** (ĕl′ē mĕnt). One of the basic substances of which the earth and everything on it is made. There are about 100 known elements. Silver, iron, gold, oxygen, tin, copper, and carbon are elements (p. 112).

**en′er gy** (ĕn′ẽr jĭ). The power to *do* something. Heat, light, and electricity are forms of energy (p. 261).

**e rupt′** (ē rŭpt′). To burst out suddenly (p. 25).

**e vap′o rate** (ē văp′ō rāt). To change into a gas (p. 28).

**ex pand′** (ĕks pănd′). To take up more room, or spread out (p. 31).

**ex per′i ment** (ĕks pĕr′ĭ mĕnt). A trial made to prove or disprove something (p. 26).

**ex tinct′** (ĕks tĭngkt′). To be extinct is to have died out. Dinosaurs are extinct animals (p. 103).

**fe′male** (fē′māl). A mother plant or animal (p. 130).

**fer′ti liz′er** (fûr′tĭ līz′ẽr). A substance which makes plants grow better (p. 148).

**fric′tion al e lec′tric′i ty** (frĭk′shŭn ăl ē lĕk′trĭs′ĭ tĭ). Electricity produced by rubbing certain things together (p. 205).

**gale** (gāl). A very strong wind blowing at a speed of 39 to 75 miles an hour (p. 49).

**gas** (găs). The state of a substance in which it holds no definite shape or volume. Air is made up of such gases as oxygen, carbon dioxide, nitrogen, and water vapor (p. 28).

**gill** (gĭl). The part of the body of some water-living animals which is used to take in air under water (p. 141).

**gla′cier** (glā′shẽr). A large field of ice which moves slowly over the land (p. 104).

**gran′ite** (grăn′ĭt). A rock which has been formed by great heat deep inside the earth (p. 107).

**graph′ite** (grăf′īt). A kind of soft, black carbon. The "lead" in pencils is really graphite (p. 123).

**grav′i ty** (grăv′ĭ tĭ). The earth's gravity is the force that pulls all things on the earth toward the center of the earth. Everything has gravity—other planets, the moon, even people (p. 166).

**grub** (grŭb). A thick, wormlike larva (p. 130).

**herd** (hûrd). A group of animals (p. 238).

**ho ri′zon** (hȯ rī′z′n). The place where the land or water and sky seem to come together (p. 69).

**hur′ri cane** (hûr′ĭ kān). A bad storm, beginning over the ocean, with winds up to 100 miles an hour (p. 49).

**hy′dro gen** (hī′drȯ jĕn). One of the elements of which the earth is made. When it is pure, it has no color or odor. Hydrogen is the lightest element (p. 113).

**in′sect** (ĭn′sĕkt). An animal with six legs (p. 6).

**in′su lat ed** (ĭn′sŭ lāt ĕd). Prepared in such a way that electricity will not pass out of the material. A copper wire covered with cotton thread or rubber is an insulated wire. Electricity will pass through the wire, but not through the covering (p. 212).

**i′ron fil′ing** (ī′ẽrn fīl′ĭng). A very small piece of iron (p. 114).

**i′ron ox′ide** (ī′ẽrn ŏk′sīd). A chemical combination of iron and oxygen. Rust is another name for iron oxide (p. 121).

**Ju′pi ter** (jōō′pĭ tẽr). The largest planet. It is fifth in distance from the sun (p. 74).

**lar′va** (lär′vȧ). The wormlike form in which certain insects hatch from the egg and in which they remain until they form a chrysalis or cocoon. A caterpillar is a larva (p. 130).

**lev′ee** (lĕv′ē). A high, man-made bank to keep a river in its bed (p. 199).

**li′chen** (lī′kĕn). Two non-green plants living together. Lichens are usually found growing on rocks or the bark of trees (p. 187).

**light′ning rod** (līt′nĭng rŏd). A metal rod connected with the earth by a strip of metal. Lightning striking such a rod on a house or barn is carried into the ground (p. 211).

**lime′stone′** (līm′stōn′). A rock made of the bones or shells of animals (p. 106).

**liq′uid** (lĭk′wĭd). The state of a substance in which it holds no definite shape, but does hold a definite volume. Water, oil, gasoline, and melted lead are liquids (p. 28).

**lit′mus pa′per** (lĭt′mŭs pā′pẽr). Paper which has been treated with a certain dye. Acid turns blue litmus paper red (p. 126).

**liz′ard** (lĭz′ẽrd). A kind of reptile. Horned toads, Gila monsters, and chameleons are lizards (p. 99).

**mack′er el** (măk′ẽr ĕl). A food fish found in the North Atlantic ocean. It grows to be about 18 inches long. It is barred with blue and green above, and is silvery below (p. 57).

**mag′net** (măg′nĕt). A piece of iron or steel which will attract things made of iron or steel (p. 166).

**mag′ni fy ing glass** (măg′nĭ fī ĭng glȧs). A specially made piece of glass which makes an object appear to be larger than it really is (p. 8).

**male** (māl). A father animal or plant (p. 238).

**mam′mal** (măm′ăl). Any animal whose young is fed milk from its mother's body (p. 158).

**Mars** (märz). The second-smallest planet and fourth in distance from the sun (p. 74).

**mas′to don** (măs′tȯ dŏn). An extinct animal which looked something like an elephant (p. 104).

**ma ture′** (mȧ tūr′). To become full grown (p. 197).

**Mer′cu ry** (mûr′kū rĭ). The smallest of the planets. It is also the planet nearest the sun (p. 74).

**mer′cu ry** (mûr′kū rĭ). One of the elements of which the earth is made. It is a heavy, silver-white metal which is liquid at ordinary temperatures. Mercury is sometimes called quicksilver (p. 30).

**me′te or** (mē′tē ẽr). A small piece of rocklike material which moves about in the solar system. Sometimes one can be seen in the air. Then it is often called a shooting star (p. 74).

**mi′cro scope** (mī′krȯ skōp). An instrument which makes a very small object look larger (p. 112).

**mi′grate** (mī′grāt). To travel at regular times of the year from one place to another (p. 242).

**min'er al** (mĭn'ẽr ăl). Materials of which rocks are formed. Iron is a mineral. Our bodies also use minerals. Such minerals as calcium and iron help to keep bodies strong and healthy (p. 117).

**mix'ture** (mĭks'tṳr). Two or more chemicals mixed together. Salt dissolved in water is a mixture. Air is a mixture of gases (p. 114).

**mold** (mōld). A small plant which grows on decaying plant or animal material (p. 10).

**mol'e cule** (mŏl'ė kūl). A very small, invisible particle of a substance. Molecules are made of one or more atoms (p. 34).

**moon** (mo͞on). A body which moves around a planet. The earth has one moon, but Jupiter has twelve (p. 65).

**nec'tar** (nĕk'tẽr). A sweet liquid produced in the flower of a plant (p. 246).

**Nep'tune** (nĕp'tūn). The eighth planet from the sun. It is the third largest of the planets (p. 74).

**nim'bo-stra'tus** (nĭm'bō strā'tŭs). A low, dark-gray, sheetlike cloud. Rain or snow may fall from these clouds (p. 57).

**nymph** (nĭmf). A stage in the lives of certain animals, such as grasshoppers. Nymphs are not full-grown animals (p. 134).

**ox'y gen** (ŏk'sĭ jĕn). One of the elements of which the earth is made. When pure, oxygen has no color or odor. Oxygen and hydrogen combine to form water (p. 28).

**par'af fin** (păr'ă fĭn). A waxy substance produced from oil or coal. It is often used to seal jars of jelly or jam (p. 38).

**pen'i cil'lin** (pĕn'ĭ sĭl'ĭn). A medicine made from a certain kind of mold (p. 12).

**phase** (fāz). One of the regular changes which seem to take place in the shape of the moon, Mercury, and Venus (p. 72).

**plan'et** (plăn'ĕt). One of the nine larger bodies traveling around the sun. The earth is a planet (p. 74).

**plan'et oid** (plăn'ĕt oid). One of the hundreds of very small planets traveling around the sun in the space between the paths of Mars and Jupiter (p. 74).

**plas'ter of Par'is** (plȧs'tẽr ŏv păr'ĭs). A white, powdery material which hardens soon after it is mixed with water (p. 39).

**Plu'to** (plo͞o'tō). The planet farthest from the sun (p. 74).

**pol'len** (pŏl'ĕn). The yellow dust found in the flowers of plants (p. 139).

**pro'te in** (prō'tė ĭn). A food material found in such foods as meat, fish, and eggs (p. 260).

**pu'pa** (pū'pȧ). The resting stage in an insect's life. The cocoon is the pupa stage (p. 131).

**quar'ry** (kwŏr'ĭ). An open pit where stone is taken from the ground (p. 106).

**quartz** (kwôrts). A hard, shiny mineral found in many rocks. Quartz is a combination of silicon and oxygen (p. 112).

**quick'sil'ver** (kwĭk'sĭl'vẽr). Another name for the element mercury (p. 30).

**re flect'** (rė flĕkt'). To turn back. When an object throws back light which falls on it, the object reflects light (p. 67).

**rep'tile** (rĕp'tĭl). A cold-blooded animal with scales or a scalelike covering, which breathes with lungs all its life. Snakes, turtles, and alligators are reptiles (p. 98).

**re volve'** (rė vŏlv'). To move in a curved path and come back to the starting point. The earth revolves about the sun (p. 72).

**sal'a man'der** (săl'ȧ măn'dẽr). An amphibian that looks something like a lizard (p. 129).

**salm'on** (săm'ŭn). A large, food fish found in both the Atlantic and Pacific oceans. Salmon are eaten fresh or canned (p. 149).

**sanc'tu ar'y** (săngk'tṳ ĕr'ĭ). A place set aside for animals, in which they cannot be harmed by man (p. 268).

**sand'stone'** (sănd'stōn'). A rock made of grains of sand cemented together (p. 106).

**Sat'urn** (săt'ẽrn). The second largest planet and the sixth from the sun (p. 74).

**shad** (shăd). A food fish, living along the Atlantic coast of North America (p. 244).

**shale** (shāl). A rock formed of clay, mud, or silt cemented together (p. 106).

**sil'i con** (sĭl'ĭ kŏn). One of the elements of which the earth is made. Silicon and oxygen form quartz (p. 113).

**slate** (slāt). A hard rock which is formed when shale is pressed greatly (p. 106).

**so'di um** (sō'dĭ ŭm). One of the elements of which the earth is made. When pure, it is soft, waxy, and silver-white (p. 113).

**sol'id** (sŏl'ĭd). A substance which keeps its shape at ordinary temperatures (p. 28).

**spi'der** (spī'dẽr). An animal having eight legs (p. 61).

**spore** (spōr). A single cell formed on some kinds of plants, such as molds, from which new plants of the same kind will grow (p. 10).

**star** (stär). One of the large bodies in the sky which gives off light in all directions. Our sun is a star (p. 65).

**steam** (stēm). The invisible gas which water becomes when it boils (p. 26).

**stra'tus** (strā'tŭs). A low, grayish cloud which looks something like fog, but does not touch the earth. Rain from stratus clouds falls as a drizzle (p. 57).

**sul'fur** (sŭl'fẽr). One of the elements of which the earth is made. Sulfur is yellow in color (p. 113).

**sus pen'sion bridge** (sŭs pĕn'shŭn brĭj). A bridge with its roadbed hung from two or more cables (p. 171).

**sym'bol** (sĭm'bŭl). A sign which may be used instead of a word or words (p. 113).

**tad'pole'** (tăd'pōl'). The stage in the life of an amphibian when the animal gets air by the use of gills (p. 143).

**tel'e graph** (tĕl'ē gräf). A system which sends messages very quickly by the use of electricity (p. 218)

**tel'e scope** (tĕl'ē skōp). An instrument which makes it possible to see many more stars and other distant objects in the sky than we would see without it. It also makes clearer any object we see in the sky (p. 89).

**tem'per a ture** (tĕm'pẽr ȧ tūr). The measure of the heat of anything (p. 30).

**ther mom'e ter** (thẽr mŏm'ē tẽr). An instrument used to measure temperature (p. 30).

**thun'der head'** (thŭn'dẽr hĕd'). A large, dark, rounded cloud often appearing before a thunderstorm (p. 45).

**tor na'do** (tôr nā'dō). A very strong, whirling wind with a funnel-shaped cloud. A tornado is very destructive (p. 58).

**tung'sten** (tŭng'stĕn). One of the elements of which the earth is made. The fine wire inside light bulbs is made of tungsten (p. 113).

**U'ra nus** (ū'rȧ nŭs). The third largest planet and the seventh in distance from the sun (p. 74).

**va'por** (vā'pẽr). A gas. Steam is water vapor. Anything turns to vapor if it is hot enough (p. 28).

**Ve'nus** (vē'nŭs). The planet second in distance from the sun. Venus is only a little smaller than the earth (p. 74).

**vi'ta min** (vī'tȧ mĭn). A food substance which is needed for good health (p. 261).

**vol ca'no** (vŏl kā'nō). A hill or mountain from which melted rocks, gases, and dust may erupt (p. 25).

**warm'-blood'ed an'i mal** (wôrm'blŭd'ĕd ăn'ĭ-măl). An animal whose blood remains at a certain temperature unless it is ill. Dogs, cats, cows, and birds are warm-blooded animals (p. 105).

**whole-grain ce're al** (hōl grān sẽr'ē ăl). A cereal prepared of the entire seed of a plant (p. 261).

**wind scale** (wĭnd skāl). A table of words or numbers used to tell the wind's force (p. 49).

**wind vane** (wĭnd vān). An instrument which shows the wind's direction (p. 63).

# Index

GINN AND COMPANY